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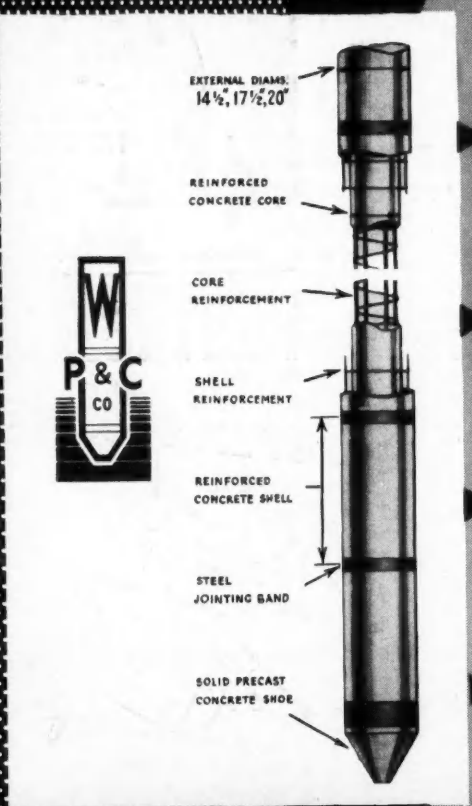

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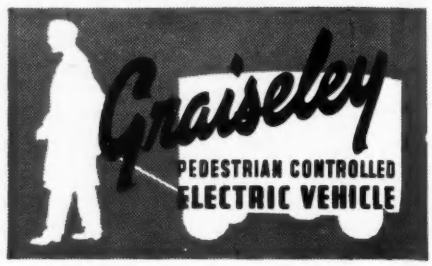

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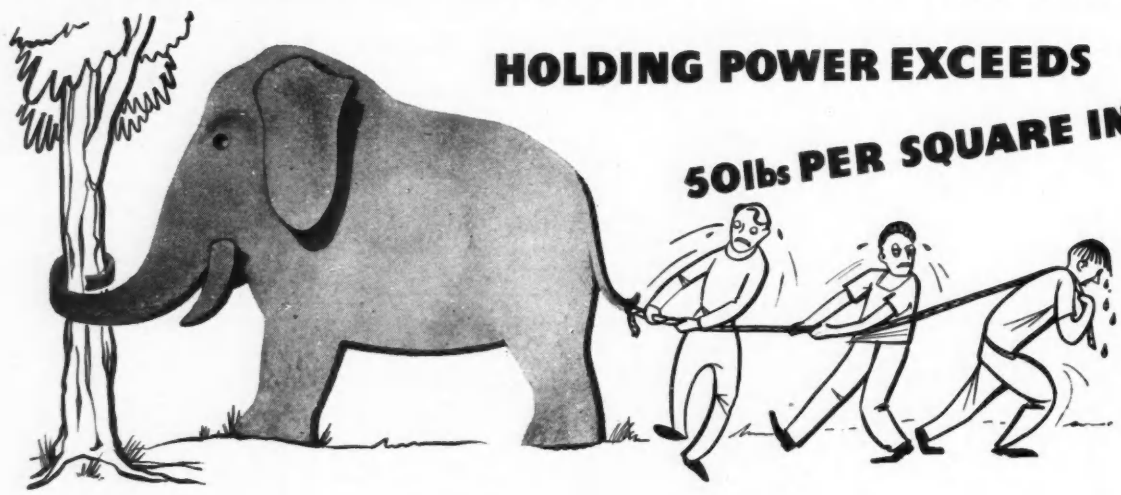

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THE INSPISSATED GLOOM OF COAL PROSPECTS

The annual report of the National Coal Board for 1955 opens with the words "Output in 1955 was disappointing. One major strike and many lesser disputes cost the industry more coal than in any year since nationalisation. Manpower fell. Home demand for coal was only met by means of excessive imports and a reduction in coal exports." The accounts showed a "deficiency" on the year's working of £19·6 million. Manpower fell by 6000 and output by nearly 3,000,000 tons compared with 1954. In 1955 there were 7000 more men at work in the mines than in 1950. Yet, despite the expenditure of close on £300 million on capital account during the interval, output at 221·6 million tons was only 5·3 million tons higher. The manpower trend has been consistently downward ever since the peak year of 1952; and if 1951 and 1952 are excluded —since they were years of recession in the textile industry and led to men taking alternative employment in the mines— ever since 1948. The accumulated deficiency of the Board has reached £36·6 million, despite price increases that have raised proceeds from the sale of coal from 40s. 3d. in 1947 to 68s. in 1955, with yet another price increase just announced. The annual report ends with a chapter on "Coal and the Future," in which it is prognosticated that despite the advent of nuclear power, demand will rise during the next twenty years and that "it does not seem likely that the demand for coal will be substantially different forty years from now." Yet the target of 240 million tons of coal per year in the period 1961–1965 originally set in "Plan for Coal," 1949, and at that time widely criticised as far too low, is now whittled down to a hope that sufficient manpower will be available to permit an output of 230 million tons a year to be reached some time in the next decade!

What inspissated gloom! One cannot feel the slightest optimism that an output of 230 million tons a year ever will be achieved or that if it were reached that an output approaching that level could be maintained for twenty years let alone forty. But let no one think us defeatist in saying that we think it as likely that coal output will in fact fall over the years to come as that it will rise. For, far from believing that the consequence would be disastrous to this country, we think it possible it might be beneficial! The trend of our thoughts lies that way because we doubt whether for a number of purposes for which it is still used, coal really remains an economic proposition. Certainly with every rise in its price it becomes less so. Long ago the shipping companies gave up coal as a fuel. Now the railways are turning towards oil fuel and electrification. Increasingly industrial users are finding conversions to oil firing advantageous. Even more significantly, the small domestic user is beginning to make inquiries into the practicability and cost of oil firing. In a world in which other suppliers of energy, the oil companies and the C.E.A., can make profits only the Coal Board makes a loss. Of the Board's nine Divisions only three are profitable at present coal prices and two of these three are affected by manpower problems largely because of the competition of other industries offering employment that proves more attractive. In these circumstances it seems to us dubious whether this country's failure to export coal is really as damaging to its balance of payments position as the Board suggests in its Report. For, to augment output from the mines men would need to be drawn thither from other industries, themselves producing goods for export. But it is by no means certain

that it would be in this country's interest to employ more people in an unattractive industry rather than to leave them in industries which, at high productivity per man, work up raw materials into finished products. There is, no doubt, an economic loss through the actual import of high cost foreign coal ; but none, we suggest, through importing oil to compete with coal, all the more particularly because an increased demand for the heavier oil fractions would improve the economy of operation of British refineries. The truth, we suggest, is that were larger supplies of alternative fuels such as oil, natural gas, or the products of underground gasification available it would already be becoming obviously uneconomic to work many British mines or to expend a great deal on mining development.

It is a curious paradox that when, during the nineteenth century Britain was regarded as "the workshop of the world" her real wealth was derived not from her engineering exports but from those of ships, coals and textiles ; yet now that she can no longer claim that proud title it is upon the quality and quantity of her workshop products that she is becoming increasingly dependent. Shipbuilding still flourishes. But the great days of prosperity in coal and textiles lie in the past. Yet it is a sign not of decay but virility when a nation is able to surmount the decline of industries once regarded as staple by the development of others. It is a change that should not be opposed. Coal we must certainly have in the future. But do we really need it in increasing quantities ? For our part we suspect that the economic interests of the country would be better served were coal prices raised to a level that would allow the Coal Board to cover its costs and were the use of oil substituted for that of coal wherever it was clear that no substantial difference in the cost of heat would be involved. As the price of coal rises in the future—as we think it certainly will—the opportunities for that substitution will widen. True the proved reserves of oil in the world are not very high. But then they never have been ! We suspect that there will be enough and to spare until nuclear power is so sufficiently developed as to relieve the pressure of demand.

STRIFE ABOUT AUTOMATION

Quite suddenly there has blown up industrial strife about the introduction of automation into industry. The trouble seems to have arisen because, despite much talk and discussion over the last couple of years, few people have really studied the human and industrial problems bound to arise as a consequence of its introduction. There has been an implicit assumption that because nationally its introduction must be gradual there would be little really to fear from trade union reactions. But now unofficially, and partly no doubt because there has been no firm trade union guidance, demands are being made that however advanced a new "automated" plant may be, the same number of men shall be employed as before, a nonsensical suggestion which negatives the very object of automation. Yet before condemning men for voicing so obviously stupid a proposition, it behoves every man to think what his own reaction would be to an "improvement" which threw him temporarily out of work and very likely forced him to take up other employment at a lower wage, in strange surroundings, and possibly at a place less conveniently situated relative to his home. Automation promises heightened living standards for all. But the promise lies wholly in the future. Its immediate effect is to threaten many with a lowering of standards. The reaction to that threat may be misguided, but is certainly quite natural ; it is to fight for the preservation of present standards, whatever may be the outcome for the future. More jam to-morrow is never regarded, even in the nursery, as a satisfactory substitute for enough jam to-day!

But, natural though it is, such a reaction is obviously dangerous. If it became normal and widespread it might delay very seriously the introduction of automation into this country's industries or cause its introduction to be accompanied by damaging industrial strife. In these circumstances, the need seems to be imperative that employers and trades union executives should both reach the agreement that as rapid an introduction of automation into industry as possible is desirable in the interests alike of the nation, employers, shareholders, and trade union members. It is, of course, too much to expect that it can be introduced without leading to intricate negotiations between the employers and the unions. For there is room for sincere differences of opinion about appropriate wage rates, conditions of work, division of profits, and so on. But unless there is agreement upon the principle, trade union executives under pressure from their members may prove inclined to fight not about the things that can justifiably be regarded as open for discussion, but against that very labour-saving principle of automation which promises to raise living standards and which they ought to welcome. Yet unless union executives can be convinced that the change-over can be accomplished without hurtful reactions for the majority of their members, even though only temporarily hurtful, how are they to face and fight inevitable prejudices amongst their men ? There lies the problem. How is a change-over to be made in any given factory without creating redundancy ? Clearly, if automation is to come as quickly as, in any individual factory, it well may, redundancy can hardly be avoided by the simple and well-known means of stopping recruitment for a few months prior to the change. The economy of manpower brought about by automation will often prove too big for that method to prove effective ; or it may prove necessary wholly to close down a shop, a department or a whole factory during re-equipment. Some other solution will need to be sought. But under conditions of full employment the problem does not seem to us necessarily insoluble, provided that there is co-operation amongst industrial firms within any area where automation is being introduced and provided the good will of union executives can be engendered. When the Minister of Labour answered questions in Parliament last Tuesday on the subject, he emphasised that the problems arising from the introduction of automation could be satisfactorily resolved. Many of those problems, he said, were already being carefully studied. Many of them no doubt are treated in the report by the Department of Scientific and Industrial Research, the publication of which is imminent. That report, it seems, is likely to provide a useful basis for the talks which the Minister proposes to have with representatives of employers, trade unions and the nationalised industries. It is to be hoped that some positive recommendations will emerge from those talks.

100 Years Ago

The Engineer

(MAY 9, 1856)

"ADJUSTMENT OF SHIPS' COMPASSES"

"At the suggestion of the Liverpool Compass Committee, and through the liberality of the Dock Committee, who will defray all the expenses, a complete system of compass bearings is about to be painted in conspicuous characters on the river side of the dock walls of that port, by which the captains of ships lying in the Mersey, through a distance of more than five miles in length, will be able in the most easy manner to detect the errors of their compasses, whether arising from local attraction or faulty construction.

"The method to be adopted appears very simple and effective. The Vauxhall chimney in Liverpool is a conspicuous object from the river, rises far above all the other buildings, and is seen from every direction. It is intended to take advantage of the circumstance by painting on the long line of river wall at suitable intervals the correct compass bearing of the chimney, and so to enable the captain—by comparing the true bearing of the chimney as seen painted on the nearest mark directly below it, with its bearing as shown by the compasses on board as the ship swings round with the tide—to obtain full tables of variation. The chances of error by local attraction on shore will be thus removed. The plan altogether is so simple and the objects to be attained so important that the example shown by Liverpool should be followed in other ports. If the labours of the compass committee were to have no other result they would deserve the best thanks of the maritime interests, but more important ones are anticipated."

A Seven Day Journal

British Electrical and Allied Industries Research Association

THE annual luncheon of the British Electrical and Allied Industries Research Association was held in London on Wednesday of last week, and was attended by some 450 guests and members. In proposing the toast of "The Association," Sir John Cockcroft spoke of the vast amount of money now being spent on research as compared with the very restricted funds which were made available for work in his earlier days. Scientific development, he pointed out, did not depend upon national frontiers, but upon the effort and expenditure which was invested in it, and in other countries, particularly the U.S.S.R. and the U.S.A., vast sums of money were now being invested in research and the training of scientists. He went on to describe briefly the developments which had been made in various fields such as nuclear fission, transistors, valves, and digital computers. In responding to the toast, Lord Chandos drew attention to the large numbers of scientists and research workers now being trained in the U.S.S.R. and America, and said that it was encouraging to note that schemes for recruiting and training young scientists were now being actively promoted in this country. Research and development, said Lord Chandos, were the lifeblood of modern industry and for that reason the work of the E.R.A. laboratories was so important to the future of industry and the country. The final speaker at the luncheon, Mr. F. H. Bramwell, considered that electrical firms should base more development work on the results of research carried out at the E.R.A. laboratories, which had not the facilities to do large-scale development. He also appealed for a greater interchange of scientists between the staffs of the laboratories and industrial establishments. Such an interchange would not only give a beneficial broadening of experience, but could serve to avoid overlapping in research, which was far from desirable with the restricted number of scientific workers at present available.

Cambridge University Engineering Department

WE have received the report for 1954–55 of the department of engineering of the University of Cambridge. The report gives a brief outline of the year's activities, both in undergraduate and post-graduate work, and also reviews research which was in progress. There has been continuous activity in overhauling the teaching courses, it is pointed out, to adapt them to changing conditions. For instance, materials teaching has been changed, and now throws more emphasis on the basic principles of physical metallurgy, including atomic and crystal structure. Research in progress during the year included, in aeronautics, studies of boundary layer suction, including flight experiments with a "Vampire" aircraft. Further progress was made in developing the plastic theory of rigid-jointed steel structures. Other work of immediate interest included the investigation into brittleness of structural steel, which is being carried out for the Admiralty; a long-term programme of research on the behaviour of non-linear servo-mechanisms and control systems, which is supported by the Ministry of Supply, and photo-elastic investigation of dynamic stresses in gear teeth, a research sponsored by the Mechanical Engineering Research Board of the D.S.I.R.

Automatic Train Control on British Railways

IN answer to a question in the House of Commons on Thursday of last week, the Minister of Transport and Civil Aviation said that the British Railways' magnetic non-contact system of automatic train control for use with the vacuum automatic brake had been under development and trial on a specially equipped length of the East Coast main line, and that the reliability of the equipment was satisfactory. The design of many component parts had reached a stage when production could be arranged. The British Transport Commission had applied for formal approval for the adoption of the system and the inspecting officers of railways had recommended the Minister's approval subject to proof of the reliability of the equipment in its production form and to final inspection. With this reservation the Minister stated that he had given his approval to the system. It was later stated by the British Transport Commission that it would announce its detailed plans for the extension of automatic train control when the inspecting officers had made their final inspection and were satisfied. It was pointed out that automatic train control would be closely associated with the extension of colour-light signalling, track circuiting, power-operated signalboxes and other aids to safer and more efficient working. The estimated expenditure under the railway modernisation plan on this kind of development included automatic train control, and was £100 million. The statement pointed out that a number of schemes of signalling improvement were already in progress or would start in the current year.

Reconstruction at Northampton Polytechnic

ON Monday of this week, Sir David Eccles, Minister of Education, opened extensions at the Northampton Polytechnic, St. John Street, London, E.C.1. The new accommodation comprises reconstruction of two "blocks" of the existing building. At the main entrance, a new entrance hall and staircase, refectories and kitchens, and, on the first floor, an examination and assembly hall, capable of seating 700 people, have been provided. In the basement of the hall block are new laboratories for high-vacuum technology, spectroscopy, photometry, electron microscopy, X-ray technology, electrical installations, advanced optics and physics research. The second new block houses aeronautics, metrology and hydraulics laboratories in the basement, workshops for production engineering on the ground floor, workshops and laboratories on the first floor for instrument engineering, measurements, instrumentation and process control, six new class rooms on the second floor and a library with space for 12,000 volumes on the third floor. With the rearrangement that the new buildings imposed, it was possible to provide several new laboratories in other parts of the building, namely, a machine and applied mechanics laboratory, a soil mechanics laboratory and a high-voltage laboratory. The new floor area is about 27,000 square feet in extent. Further extension schemes are now being planned, which, it is envisaged, would provide further accommodation equal to about 50 per cent of that now available in a compact block contiguous with the present main building on its northern side.

Speeding Up Goods Vehicles at Docks

THE third report of the Ports Efficiency Committee, which has just been published, urges the improvement of transit sheds and the introduction of schemes to regulate the flow of traffic on roads within the docks. Other recommendations made in the report relate to the greater use of rail transport and the creation of depots for bulking small consignments. The Report also refers to the need for the co-operation of all parties concerned with traffic at the docks and for dovetailing the various port operations in an orderly manner. The committee says that although only a small percentage of vehicles are held up at the docks, the delays in total present a serious problem. The committee's inquiries have shown that delays mainly occur to vehicles loaded with general export cargoes, particularly, though not exclusively, those consigned to deep-sea ships bound for distant parts. The report analyses the position in London, Liverpool, Manchester, Glasgow and Southampton. About London, the committee recommends that greater use should be made of the depots already provided by the Port of London Authority in the Royal Docks and the India and Millwall Docks for the reception of small consignments up to a total weight of 20 cwt. The report is confined to the problem as it affects road transport within the docks and does not deal with road transport to the ports which, the committee says, is a separate matter.

Dr. S. Whitehead

WE regret to have to record that Dr. S. Whitehead, Director of the British Electrical and Allied Industries Research Association, died suddenly at his home in Hampton-on-Thames on Saturday last. Dr. Whitehead was born in Sutton, Surrey, in 1902 and was educated at Sir Walter St. John's School, Jesus College, Oxford, and Queen Mary College, London. He was a research scholar in the Clarendon Laboratory, Oxford, from 1924 until 1925, when he joined the Electrical Research Association as a technical assistant. His career then was very closely linked with this Association: he was appointed assistant director in 1939, acting director in 1945 and director in 1946. As director he was largely responsible for piloting the project for the Association's new laboratories at Leatherhead. In a few months, but for his untimely death, Dr. Whitehead would have seen the first results of many years of patient work, for the Leatherhead laboratories are now nearing completion and most of the staff and equipment are due to move from the Perivale laboratories to Leatherhead by the end of June. Dr. Whitehead was a member of the Royal Institution and served as Manager in 1953 and 1955. He was chairman of the measurements section of the Institution of Electrical Engineers in the 1948–49 session. From 1954–55 he was chairman of the committee of Directors of Research Associations and from 1954–56 he served as joint honorary secretary of the Parliamentary and Scientific Committee. He was honorary treasurer of the Institute of Physics and a past vice-president and chairman of its London branch. He was the author of more than thirty technical papers and books, including *Dielectric Breakdown of Solids*, and a treatise in three volumes on *Dielectric Phenomena*. Dr. Whitehead was a Fellow of Queen Mary College.

Impact of Engineering on Society

By Sir MAURICE BOWRA, F.B.A., M.A.*

No. II—(*Concluded from page 434, May 4th*)

The second Graham Clark Lecture was presented on Friday, April 27th, before a joint meeting of the Institution of Civil Engineers, the Institution of Mechanical Engineers, and the Institution of Electrical Engineers. It is here reprinted nearly in full. The author is not an engineer. But he suggests "it is often profitable to see ourselves as others see us, especially if we practise some highly skilled and specialised pursuit." He turns out to be a kindly and entertaining critic.

NOBODY who is interested in human beings can fail to take pleasure in their enchanting variety, not merely in their individual differences, but in their differences of customs and thought and circumstances. The great humanistic tradition which has dominated our thought for some 400 years accepts the variety of men as something delightful and desirable in itself and judges the worth of a civilisation by its ability to sustain the widest variety possible. When we think of the rich range of existence which was taken for granted in Italy in the fifteenth century, or in France in the nineteenth, we cannot but feel respect for the ideal which holds that freedom expresses itself in variety, and that variety is a test of the richness of life. Conversely, to conform to a standard pattern seems to be an admission of defeat, of an inability to get beyond mere existence to a good existence, of a lack of enterprise and ultimately of a real self. Anyone who likes the human species and enjoys its capacity to express itself in different ways, must surely be a little alarmed by the formidable drive towards conformity in our time. It is, of course, partly a political matter. The governing class of Russia spares no pains to turn its curiously assorted victims into a respectable imitation of the old bourgeoisie, and its motives are clear enough. It feels that once such respectability is established and becomes common form, the whole business of government will be easier and safer. In the United States the desire for conformity is no less powerful, but comes not from above, but from below, from a real desire to have a common, American way of life, in which everyone feels at home and knows that he will not be troubled by anomalies and eccentricities. But though the drive towards uniformity is undeniably political in its origins, it has undeniably found a powerful ally in engineering.

The revolution of communications has meant a vast change in traditional ways of life by the introduction of standard, international objects of every kind. The process which began with the bicycle and the sewing machine has extended to most mechanical devices, and no doubt Bokhara is as proud of its up-to-date materials as Peking. Yet on the whole this air of "Westernisation" is probably more superficial than we think. Of course, there is an international level of comfort which spreads along the main lines of communications and supplies the same meals, the same drinks and the same opportunities for hygiene wherever it occurs, but this after all is meant for foreigners and does not touch the local inhabitants. They will maintain their own *cuisine bourgeoise* and reject all temptations to be "Ritzy" in their *confort moderne*. Indeed, the spread of Western gadgets to Asia may even have its own charm. It is the modern equivalent of the Baroque Churches which the Portuguese built at Goa and Macao, or those resplendent palaces which the English built in the best Regency style at Hyderabad or Corfu. We cannot expect any material civilisation to remain static, and the archæologists of the future will probably be as delighted to find remains of gramophones and wireless sets in Ulan-Bator as their present counterparts are to find Roman coins and pottery in Travancore.

Nor need we deplore the way in which most languages now absorb with consummate ease words from other countries. The French have long set a mysterious example with their use of "un footing" or "un dancing," but there are few languages which do not yield to the same temptation. For a time the Chinese resisted the adoption of foreign words and preferred to call whisky "fire-water," but I am told that this is now out of fashion and whisky is simply whisky, just as the Bulgarian for "mackintosh" is "mackintosh." The Russians, who began by calling a railway terminus "voksal," which comes from Vauxhall, have from time to time resisted foreign words, but now, like the Chinese, have given up the struggle. Even modern Greek, torn as it is by dissension between using a stiff Byzantine, "pure" language and the lively varied speech of the common people, cannot resist such modernities as ἀμανέξ and αἰλαίφ. Most languages have a remarkable gift for absorbing words from abroad. The process is probably as ancient as civilisation, and the first Greeks were delighted to take over such pre-Greek words as those for such non-Greek things as bath-tubs, beams, hyacinths and wicker-baskets. When the Germans insist on calling the telephone "Fernsprechen," they show an unbecoming nationalism, and an ignorance of the laws of that philology to which they have given such patient and untiring toil. These linguistic oddities have, of course, increased with the increase of communications, but they do not in fact detract from the charm of the languages which assimilate them.

Engineering and Individuality

A more serious charge against the influence of engineering is that it interferes with the variety of the individual self and shapes it to a uniform mould by imposing certain patterns on it through modern organs of indoctrination such as the Press, cinema, wireless and television. It is claimed that these means of instruction and propaganda are far more tyrannical than the old-fashioned means of books because they are cut to a close pattern and allow very little choice. It is perhaps not enough to say that we need not listen to them unless we wish; for sometimes we may be in a mood to listen to anything, and then, it seems, the deadly work begins. Now, of course, if we compare the means of information which the ordinary man of to-day has in comparison with the privileged man of a hundred years ago, there is no doubt that it is more stereotyped and far more likely to create what is disagreeably called a mass mind. The danger is indeed great when these means of information are controlled by a single authority which wishes only certain things to be known, and those not necessarily true. We have seen this happen in Germany and Russia, and we know how dangerous it can be when even the most honest and independent people are so circumscribed in their sources of information, and so cut off from any other sources, that they are almost forced into certain opinions. Hardly less dangerous is the situation in relatively free countries when an exaggerated respect for the views of misguided, but touchy, minorities forbids the public expression of anything which might cause them pain. Truth flourishes on controversy, and when the B.B.C. seeks to avoid it or to reduce opposite points of view to a woolly muddle, it betrays its heritage and shirks its chief duty.

Against this somewhat depressing prospect we may set certain considerations which carry some weight. The whole of this new system of imparting information, to call it by no ruder name, is still in its infancy. It is quite possible, of course, that it may grow much more powerful and exert a more stifling influence than at present. We must at least be awake to this possibility and beware of it. On the other hand, we may safely assume that the whole machinery of broadcasting and television will grow to such an extent that before very long anyone in one part of the world will be able to see or hear a programme from any other part. No doubt powerful efforts will be made to stop this, but it is unlikely that they will be any more successful than efforts have been in our own time to stop listening to forbidden programmes from London or Berlin or Athens. As the programmes multiply, the innate curiosity or perversity of men will lead them to pay attention to much which is not supposed to concern them. In their early days these vast new means of propaganda have indeed been formidable instruments for imposing at least a superficial uniformity, but we may well doubt whether they will keep their supremacy.

Another source of hope, if not quite of confidence, may be found in the undeniable tendency of men who have a special, difficult job, to think for themselves. However bad their original education may have been, once they master a technique or a technology, they are almost forced to shape their own philosophy on it. They know it so well that they cannot help noticing at times that facts are not what they are commonly said to be, that there is more than one way of looking at a problem, that what may work as a passable truth in other professions does not work in theirs. This consideration is of first importance in a world where technology of every kind is becoming more complex and more difficult every day. Just because many tasks are more specialised, they demand a higher degree of trained intelligence, and do much of their own training for it. The job makes the man and shapes his critical sense of reality. It is a false criticism to say that specialisation narrows the intelligence. On the contrary, it is usually when we are specialists in one thing that we are able to look at other things outside our own sphere with a new detachment and insight. Of course, this implies a reputable degree of education, but that, too, is indispensable if we are to have the specialised technologists whom we need. You cannot set a man to work a difficult machine if he is unable to think within reasonable limits. So in the end it looks as if engineering, which has undoubtedly played into the hands of some of our new bosses by its skill in shaping thoughts, will change its direction and make it easier for those thoughts to be free.

A final objection raised to engineering in social life is that it imposes a standard of

* Warden of Wadham College, Oxford.

culture which lacks the variety and the beauty of the old craftsmanship, that it substitutes the dead products of machines for the fine work of men's hands, that it destroys the grace of life even in the small, select circles where it is still cultivated. Now it is perfectly true that most machine-made articles have not the charm and the distinction of Chippendale or Wedgwood, that concrete lacks the variety of texture and colour to be found in stone, that mass production must inevitably destroy the old delight of the eyes in things made by hands. It may well be the case that increased production will spoil some of the old fine art of workmanship. But we should not allow this to get out of proportion or wrong conclusions to be drawn from it.

Some historians maintain that civilisation becomes degraded as soon as the cultivated tastes of a few are shared by many. It has even been claimed that this was one of the main factors in the decline of the Roman Empire. This certainly is not true. In the Roman Empire one of the chief causes of decline was the ever-increasing gap between the rich and the poor, and the consequential limitation of arts and sciences to a very small class. Nor is the theory true of modern times. The countries which have shown the greatest intellectual and social advances—France, Great Britain and the United States have all managed to extend their refinements to an ever-increasing class. Of course, such a process will show its growing pains. Of course, there will inevitably be failures of taste. Of course, there will be maladjustments and mistakes and pretentious impostures. But there is no real reason why a world which relies on machines more than on handicrafts should not in the end produce objects as satisfying as those of the old craftsmen. They will be in more generous supply. They will not be unique treasures. But they will give delight to a far greater number of people than the old system of privileged elegance could ever do, and in the end man's natural desire to do things well will triumph, and a new kind of grace and charm will emerge.

As the Greeks said, "even the gods do not fight against necessity," and for us engineering has become a necessity. It is madness to fight against it, to wish that it had never been. It has brought untold benefits to the world, and if it has often enough been held responsible for our catastrophes, it is we, and not it, who are to blame. I even cherish the hope that it may help to solve some of our political troubles. In so far as it offers by far the surest and safest way to improve the human lot, is it perhaps not too much to hope that in the end the majority of mankind will see that it is far saner to alter social conditions by its controlled and rapid methods than to revert to violence, which always means that an unforeseen situation is created and that too much has to be done all over again? Man's unique position in the scheme of things lies in his ability to turn nature to his own ends, and if he really knows what these ends are, he should be able to do on an ever-extended scale what he has already begun to do with such imagination and devotion and skill.

Mechanical Handling Exhibition

No. I

The fifth Mechanical Handling Exhibition and Convention was opened at Earls Court, London, on Wednesday last, May 9th, and will remain open until Saturday, May 19th. More than 250 manufacturers are showing their latest equipment at the exhibition. Authors from this country and overseas will present papers on mechanical handling problems and developments at the conference, the theme of which is "Mechanical Handling is Vital to International Commerce."

MATERIALS handling affects all branches of industry in some measure, and not infrequently provides the key to economic production or distribution and the difference between profit and loss. Despite this fact, other than in cases where loads were beyond normal human capacity or excessive in bulk, it has only been during relatively recent years that serious attention has been given to the scientific development of mechanical equipment for handling and transferring materials in many important industries. This change of attitude has in some measure been due to the shortage of suitable labour, and probably in greater degree to the work done by manufacturers of material handling equipment in developing ways and means of handling loads of all kinds and proving the economies which can be achieved with mechanical equipment. But the main reason in many industries for the development and introduction of mechanical handling plant is the problem created by the vast increases in productive efficiency of modern manufacturing methods and machines, which makes it essential to feed, transfer and remove materials at ever increasing speeds. All who are connected with industry are now fully aware of the fact that the introduction of mechanical equipment for the transfer of components and materials between machines, in processing plant, in stores, transport, &c., can lead to considerable savings in manpower and in time. For this reason the applications of mechanical handling are continually widening with the introduction of new and improved plant and methods, and it is the object of the organisers of the Mechanical Handling Exhibition to provide industry with an opportunity to inspect and compare the developments made in handling plant during the two years which have passed since the last show.

The exhibition covers an area of 400,000 square feet, and as in previous years much of the smaller plant can be seen in operation whilst many of the larger pieces of equipment are shown in model form. The plant exhibited includes typical conveyors, overhead runways, aerial ropeways, elevators, trucks, tractors, cranes, lifting aids, loading equipment, vibrators, stores racks, containers, pallets, stillages and a variety of the ancillary equipment which is designed to increase industrial capacity with safety and to speed handling. A demonstration area has been set aside for showing large mobile equipment handling various commodities and materials.

Cranes

Cranes are once again a prominent feature of this exhibition. One of the new mobile cranes on the stand of George Cohen and Sons, Ltd., is the Jones "KL33," a 3 tons capacity crane powered by a two-cylinder air-cooled diesel engine, and which is available with a number of mountings. One of these cranes on the stand is mounted on a pneumatic-tyred chassis with four-wheel differential drive and it has four-wheel steering, which gives it exceptional manœuvrability and a turning circle of only 13ft radius. Another new machine is the Jones "KL66" 6-ton crane, which has a hydraulically derricked cantilever jib and can be supplied with jibs up to 65ft long.

Last year Ransomes and Rapier, Ltd., of Ipswich, introduced a mobile crane of from 7½ tons capacity at 4ft 6in outreach to 3¾ tons at 11ft 4in outreach, which was designed to give road travelling speeds higher than usual for inter-depot service such as on railways or road haulage systems. These cranes, one of which is exhibited, are fitted with lattice-braced cantilever jibs and are carried on pneumatic-tyred wheels. Four wheels are mounted in twin formation on the front driving axle and two on the rear steering castor. The design is such that the crane always remains steady on its wheels and its stability is maintained under all working conditions without the use of props or jacks. If it is grossly overloaded the tail of the crane tends to rise instead of the load being lifted, and this gives the driver ample time to correct his mistake before the crane becomes unstable.

The crane is powered by a Perkins "P.6" diesel engine developing 70 h.p. at the maximum governed speed of 2000 r.p.m. and has forward travelling speeds from 3·4 to 10 m.p.h. and reverse speeds from 3 to 8·7 m.p.h. When loaded it can climb inclines of 1 in 5 and when unloaded 1 in 8.

The axle of the steering castor is pivoted in a king post at the tail of the crane so that its wheels can accommodate themselves to uneven ground and ensure that the crane is always supported on three points—the two front wheel points and the castor post. The hoisting and derricking motions are each driven by a 10 h.p., 1200 r.p.m. motor, to which current is supplied by a compound wound dynamo driven by the main engine.

One of the five "Coles" cranes shown by Steels Engineering Products, Ltd., Crown Works, Sunderland, is the heavy-duty truck-mounted machine illustrated in Fig. 1, which is designed to withstand the severe conditions encountered on undeveloped sites and rough terrain. For the exhibition the crane is fitted with an 80ft lattice jib, with which it has a lifting capacity of 11 tons at 15ft radius. With a standard 30ft jib, the crane can lift up to 20 tons at 10ft radius; this design of jib can be lengthened by the introduction of standard extensions.

The three crane motions of hoisting, derricking and slewing are operated by separate electric motors, for which direct current is supplied by a variable speed generator, coupled directly to a diesel engine. These motions can be used simultaneously or individually. Electro-mechanical brakes come into action automatically on the hoist, derrick and slew motions should the power supply be interrupted, and automatic self-resetting limit switches are fitted to prevent hoisting or derricking beyond the prescribed limits. A dynamic braking system, which is not standard, has been fitted on the machine exhibited, and this gives an extra margin of safety when lowering the heaviest loads through the maximum distance from the head of the longest jib.

The crane is mounted on a rigid, six-wheel-drive chassis, powered by a six-cylinder Rolls-Royce engine. From this engine power is transmitted through a single dry-plate clutch and a six-speed main gearbox and an auxiliary gearbox, to the mid and rear axles for ordinary road work when a four-wheel drive is used, or to all three axles for severe travelling conditions when the six-wheel drive is required.

Foot-operated air brakes act on all six road wheels and the hand brake, which is coupled by mechanical linkage to the same shoes, acts on the four rear wheels.

In order to ensure the best possible performance with the crane on rough and uneven ground, the ground pressure of the tyres is set low at 55 lb per square inch instead of the usual 90 lb per square inch. The two rear axles of the crane carrier are mounted on specially designed rocking beams which are pivoted centrally to the chassis frame. Each axle is free to pivot independently of the other, so that the wheels maintain their full tractive ability by automatic adjustment to ground conditions. A torque arm attached to each axle counteracts driving and braking torques which develop when starting and braking the vehicle. The ground clearance of the vehicle is set particularly high, at 21in. The use of power-assisted steering gives light control of the machine and reduces operator fatigue whilst providing full manœuvrability even under the worst conditions. A screw tail-weight relieving gear prevents loads, due to the weight of the superstructure, being transmitted to the centre post of the crane when travelling.

Fig. 1—Truck mounted mobile crane specially built for working on undeveloped sites. With a standard 30ft jib the crane lifts up to 20 tons at 10ft radius—Steels Engineering

A diesel-electric rail-mounted crane exhibited by this firm is designed to lift 20 tons at 10ft radius with a 30ft jib. Each of the four motions of this crane—hoisting, derricking, slewing and travelling—are powered by separate electric motors. Power is supplied from a diesel-engine-driven, variable-speed generator mounted at the rear of the crane. The machine is carried on two four-wheeled bogies arranged for 4ft 8½in gauge track.

Just over a year ago Priestman Brothers, Ltd., of Hull, developed a truck-mounted shovel crane which was particularly intended for the Canadian market and is now known as the "Caribou." This machine is designed for use with six front-end equipments including the firm's standard ¾ cubic yard crowd shovel and drag shovel fittings. When arranged as a crane it has a capacity of 6 tons at 10ft radius with a 25ft jib and, using outriggers, about ½ ton with a 65ft jib at 50ft radius. The crane (Fig. 2) is mounted on a six-wheel drive chassis and is powered by a Perkins engine rated at 108 h.p. at 2700 r.p.m. Power is transmitted through a single dry-plate clutch to a four-speed gearbox giving road speeds ranging from 30 m.p.h. to 1 m.p.h.

The crane superstructure rotates on a large diameter roller race and its machinery is driven by a Dorman 33 b.h.p. at 1125 r.p.m., three-cylinder diesel engine. From this engine power is transmitted through roller chains to the gearing for the hoisting and slewing motions. A gear is fitted for crowd shovel operation and the firm's "Autotrip" bucket discharge mechanism which can be fitted for the crowd shovel is operated by a thumb-button on the main slewing lever.

Also shown by Priestman Brothers, Ltd., is one of the "Air Cactus" compressed-air-operated grabs developed for high-speed sinking of deep mine shafts in South Africa. This form of grab is suspended from a special hoisting mechanism lowered down the shaft, and it is simply used to pick up material from the shaft floor and load it into buckets for hoisting to the surface. The grabs, which are operated by a double-acting air cylinder designed for an operating pressure of 80 lb per square inch, are made in three capacities of 12, 20 and 30 cubic feet.

The use of tower cranes for constructional work has grown rapidly in this country during recent years and a number of continental designs are now being imported and built under licence in Britain. A new machine of this type which is of British design and manufacture is shown by Butters Brothers and Co., Ltd., MacLellan Street, Glasgow. This crane is a travelling machine and is designed to lift from 3 tons at 30ft radius to ¾ ton at 80ft radius.

Trucks

A recent development of Conveyancer Fork Trucks, Ltd., Liverpool Road, Warrington, is a fork lift truck known as the "Overlander," which is intended for site working conditions such as are experienced on public works contracts, airfields and stock yards. A typical arrangement of one of the new trucks is shown in Fig. 3. It is a four-wheel-drive, four-wheel-steering vehicle equipped with large diameter pneumatic tyres and powered by a six-cylinder diesel engine. Power is transmitted through a hydraulic torque converter and a pneumatically controlled epicyclic gearbox. An auxiliary gearbox which is fitted is designed for four forward and one reverse speed in each direction. With this arrangement the machine, as a road vehicle, has four forward speeds up to about 30 m.p.h. and one reverse speed. When operating as a fork truck a lower range of four forward and one reverse speed is used.

The stacking unit fitted to the "Overlander" is of the firm's conventional pattern with the usual 2 : 1 lift. The lifting mast can be tilted forwards and backwards and the lifting and tilting operations are hydraulically controlled by hydraulic jacks, fluid pressure for which is provided by a hydraulic pump mounted on the transmission unit. The lifting mast incorporates a roller mounted carriage which is designed to carry the lifting forks; alternatively, a crane arm or other attachment can be fitted.

Steering of this machine is power assisted by hydraulic booster jacks which do not operate for small steering efforts but come into effect for larger efforts when the driver must provide a fixed proportion of the effort so that he can, at all times "feel" the steering. The design of the steering is such that four-wheel or two-wheel steering may be selected to suit either fork lift truck duties or road travel duties. The controls of the truck include two steering hand-wheels and an adjustable swivel pedestal seat which enables the driver to face either direction of travel.

An interesting attachment for fork trucks on the Conveyancer stand is a new "Load Clamp," which enables cartons, boxes or crates to be handled without the use of pallets. It consists essentially of two side clamping plates which close in on the stack of cartons or boxes to grip it with a predetermined pressure which is sufficient to support but not crush the load. These clamping plates are actuated by two parallel, double-acting hydraulic jacks which move in opposite directions to close or open the plates. The jacks are operated by the fluid of the truck hydraulic system and the maximum pressure they exert is governed by a relief valve, an additional manually-operated valve being fitted to control the amount of squeeze pressure on the load to suit the type of product being handled.

Two clamping plates are fitted on each side and to ensure their automatic alignment during

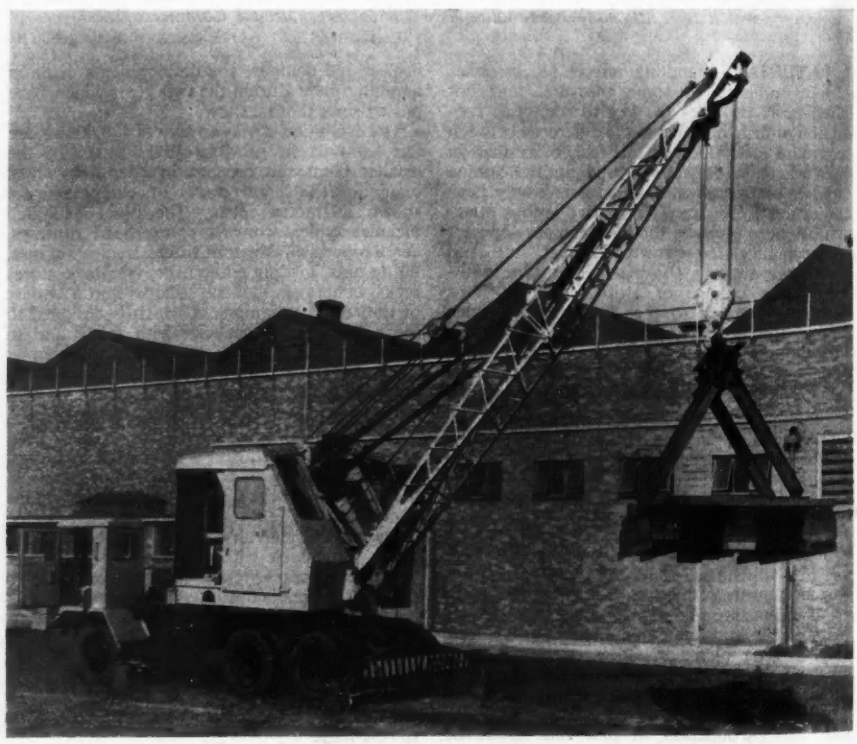

Fig. 2—"Caribou" truck mounted crane which can be converted into a crowd shovel, dragline, drag shovel or grab crane—Priestman

Figs. 3 and 4—(Left) "Overlander" fork lift on a four-wheel drive, four-wheel steering vehicle working on rough terrain—Conveyancer. (Right) Flameproof battery truck with a payload of 1 ton—Brush

load pick-up each pair of plates is pivoted on two compensating beams, one on each side of the attachment. These beams are in turn pivoted on the clamp arms actuated by the jacks, and the plates are spring loaded against the arms. Provision is made so that the distance between the opposite sets of clamping plates is at the top and is slightly more than that at the bottom, to provide vertical "toe-in."

The fork trucks shown by Ransomes, Sims and Jefferies, Ltd., Ipswich, are fitted with some typical load handling devices. One machine of 1120 lb capacity at 15in centre has an overhead load stabiliser which automatically clamps a load as it is lifted and releases it on discharge. A similar machine has side shift and free lift equipment to facilitate operation in restricted areas.

Fig. 5—Fork truck with slewing mast which enables a long load to be carried in line with direction of travel—Ransomes and Rapier

A heavier machine of 2000 lb capacity is fitted with a "Hydrum" load clamp for handling bales, bins and bundled goods without the use of pallets, and another has a reel clamp for the transport and stacking of heavy paper reels.

Early last year Ransomes and Rapier, Ltd., Ipswich, introduced an interesting new design of heavy duty fork truck with a slewing mast which facilitated the handling of long loads in narrow gangways by enabling a load to be carried in line with the direction of travel, as shown in Fig. 5. This truck, which was described in detail in our issue of January 21, 1955, can be used to advantage in stockyards where timber, poles, rails, pipes, steel sections, &c., are stored in a series of stacks, or sets, as they are called, arranged end to end and running back to some depth from the sides of comparatively narrow gangways. In such cases the stacks to the full depth of a set, and those at the rear of a transverse path to the back of a depleted set, can be handled without disturbing the stacks in adjoining sets. The truck is driven into the required set with its forks in their forward position and a load from a stack raised in the usual way. The truck is then backed out from the stack and by combining the mast slewing and the steering movements when it reaches the main gangway, the load can be aligned with the axis of the machine and supported along its side for transport lengthwise along a narrow road. The slewing mast also makes easy the negotiation of sharp corners when transporting long loads, as the load can be raised and turned independently as required, whilst the operator is steering the truck. The truck, which has a turning radius of 12ft, is designed to lift loads of 12,000 lb at 24in from face of forks and it has a standard lift height of 12ft 6in. In full working order it weighs just over 10 tons.

Brush Coachwork, Ltd., of Loughborough, has introduced a flameproof truck based upon the firm's standard industrial battery truck and having a payload of 1 ton. The self-contained driving unit of the truck (Fig. 4) consists of a flameproof series-wound motor developing 2·3 b.h.p. at the one-hour rating, and a reduction gear. Final drive to the axle is by spur gears and the complete unit, to which the steering handle is attached, can be removed by undoing eight bolts and disconnecting the motor leads. The controller is mounted in a flameproof enclosure, and gives five speeds in both directions of travel. The battery consists of twelve lead acid cells and in order to give overload protection a circuit breaker in a flameproof housing is fitted to the battery box. Automatic charging equipment is provided and is designed to charge the battery fully in ten hours.

Two new products of the Yale and Towne Manufacturing Company, Wednesfield, Wolverhampton, are being demonstrated—a hydraulic hand-lift truck and a 2 tons capacity, rider, platform truck of the "Warehouser" series. This electric platform truck (Fig. 6) is available with three widths and five lengths of platforms, and each has a lift of 4in. Drive from its series-wound high-torque motor is transmitted through double-reduction spur gearing to the axle, and the complete assembly is mounted on a ball

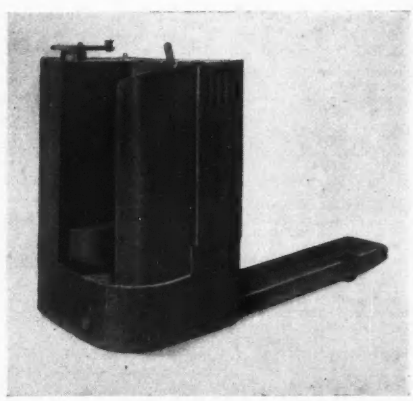

Fig. 6—Two tons capacity electric platform truck—Yale and Towne

bearing steering ring. The brake on a drum at the end of the driving motor shaft is applied by a spring load and released hydraulically.

The platform is elevated through a system of links by a hydraulic cylinder, low-pressure hydraulic fluid for platform lift and brake operation being supplied by a separate motor-driven pump. The driver has four main controls, a steering wheel on the left, with a conveniently close lever for hoisting and lowering the platform; a central speed control lever, and a dead-man pedal which cuts off power and applies the brake when the left foot is raised. The truck can be driven at three speeds, up to 4 m.p.h., when fully loaded, and it is fitted with time-delay controls to ensure smooth acceleration.

(To be continued)

INTERNATIONAL CONGRESS ON PORTS AND WATERWAYS.—An international congress is to be held in London in 1957, from July 8th to 16th, for the exchange of information on the construction, equipment and operation of ports and inland waterways. The congress is the nineteenth of its kind organised by the Permanent International Association of Navigation Congresses, members of which comprise governments, corporations and private individuals throughout the world. Of the eighteen congresses held since 1885, only two have met in the United Kingdom. The first was in Manchester in 1890 and the second in London in 1923. To produce a programme worthy of the occasion, we are informed, a strong British organising committee has been formed under the chairmanship of Sir Arthur Whitaker. The secretary of the congress is Mr. A. C. Morrison, Ministry of Transport and Civil Aviation, Berkeley Square House, London, W.1.

Electrical Equipment in Aircraft

A convention on electrical equipment of aircraft was held by the Institution of Electrical Engineers in London from May 2nd to 4th. The proceedings under the chairmanship of Sir George Nelson, president of the Institution, were divided into six sessions, dealing with electricity in aircraft, aircraft electrical systems, machine equipment, system equipment and installation and maintenance. In all, eighteen papers were presented. Abstracts are reproduced from the first of these papers, "Electrical Equipment in Aircraft: Survey of Past and Present Practice and Future Trends in Design," by S. F. Follett, B.Sc. (Eng.), M.I.E.E.

IN the modern aircraft, the electrical supply is becoming increasingly used for functions of a varied nature. Table I lists some of the applications of electrical power which may be found in a modern aircraft, with their approximate consumptions.

The generality of aircraft designed after the end of the second world war required a large increase of electric power to meet the increased uses of electricity incorporated in these machines.

TABLE I

Application	Type of supply	Special requirements of supply	Approximate power consumption
			kW
Radio-communication equipment	D.C. primary supply	Voltage regulation	1
Radar bombing and navigation equipment	400 and 1600 c/s, 3-phase and single-phase	Voltage regulation within ±2 per cent; Frequency regulation within ±2 per cent; Voltage modulation not to exceed 15 per cent	12
Special gyroscopic equipment	A.C.	±0·05 per cent frequency tolerance	0·1
Instrument supplies (gyro-compasses, artificial horizons, position-indicating devices (synchros), &c.	400 c/s, 3-phase	Voltage and frequency regulation within ±5 per cent	1
Automatic pilots	400 c/s 3-phase	Voltage regulation within ±5 per cent	0·50
Gyro gunsight	D.C. primary supply	—	0·15
Fuel pumps	D.C. primary supply	—	5
Flying controls	D.C. primary supply	—	10
De-icing: (a) Airframe; (b) Windscreens; (c) Propellers	Primary supply or special generator	—	30–60
Undercarriage operation	D.C. primary	—	50
Food heating	D.C. primary	—	0·6
Camera supply	D.C. primary supply	—	6
Gun firing	1400 c/s	—	0·050 (short rated, e.g. for 1 minute)
Landing lamps	Primary supply	—	0·5
Navigation lights	Primary supply	—	0·050
General lighting	Primary supply	—	0·150
Engine-control instruments	400 c/s	—	0·200
Bomb-release circuits	D.C. primary supply	—	—

Table II shows the average consumption of the major loads on one modern bomber with 112V d.c. primary supply.

The new turbo-jet engines had a wider speed range between idling and take-off speeds than the reciprocating engines previously used. In view of the increased loads, it was not now economic to rely on accumulators to supply power when, with engines throttled back in taxi-ing, in a glide or when landing, the generator speed was insufficient to give full voltage. It was therefore necessary to design new generators to cover a wider speed range to ensure that they supplied power whenever the engines were running, and the battery was only used to supply power when the engines were stopped. Such generators would be heavier, but the voltage regulation of the system would be improved and some economy in weight of equipment was possible, since, with a few exceptions, it was no longer expected to function effectively at the low voltage of the discharging battery.

TABLE II—*Estimated Average Loads on 112V Busbars of Typical Modern Bomber Aircraft*

Service	Load
	kW
Flying-control motors	11·2
Rotary transformers for 28V d.c. secondary supply	9·2
Inverters for 400 c/s and 1600 c/s a.c. supply for radar equipment	8·3
Fuel pumps	5·2
Inverters for 400 c/s supply for auto-pilot and radar	2·6
Demisting heater	1·0
Radar amplidyne	0·9
Battery heater	0·5
Battery charging	0·5
Total	39·4

The speed range of the earliest turbine engines was as high as 5 to 1, but a speed range of 3·5 to 1 was found sufficient for later engines. To produce full load over this speed range raised difficult design problems in securing stable operation and good commutation over the great range in excitation required. The requirement for full load at the lowest speed was a governing factor in the generator weight and placed a premium on higher speeds of rotation. Conventional d.c. generators to meet these requirements were developed. Alternative methods were also investigated, and rectified-a.c. systems in which the outputs of engine-driven alternators were rectified by metal rectifiers and the d.c. outputs subsequently paralleled were successfully applied in several aircraft. This method had further advantages in that, by the use of suitable transformers and control gear, alternative d.c. voltages, usually 112V or 28V (nominal), were available, together with "raw a.c." of varying frequency but controlled voltage for supplies to heating and de-icing circuits and similar loads.

The increased loads in post-war aircraft necessitated a higher supply voltage, and, while alternating current had considerable advantages, the lack of means at that time of providing a constant-frequency supply with paralleled generators suitable for aircraft application led to the continued use of direct current, but at 112V (nominal) for the main supply. Aircraft are in use with 112V d.c. systems using conventional d.c. generators[1] and with rectified-a.c.[2] systems, the choice of system depending on the electrical demands. The rectified-a.c. system has advantages when a large heating load has to be carried.

FUTURE TRENDS

Temperature Effects.—The most difficult problem to be met in future aircraft will be that of the effects of high temperatures due to passage through the air at transonic and supersonic speeds. As an example, the rise of temperature at a Mach number of 2 may amount to 175 deg. Cent. at ground level and 130 deg. Cent. at 50,000ft.

In fairly prolonged flights, the ambient temperatures inside the aircraft may be expected to rise to temperatures approaching those of the skin. The pilot or his compartment must be cooled and refrigeration will have to be provided for this purpose. Some refrigeration may also have to be supplied for equipment which cannot be developed to withstand these high temperatures. It is obvious, however, that the amount of cooling must be kept to a minimum to reduce the weight of the refrigerating equipment and of the extra fuel consumed.

Consideration of the heat-resisting properties of the best insulation now available and of the inlet temperature of air obtained by scoops on the aircraft surface shows that above a speed of about Mach number 0·8 cooling of equipment by the conventional ram-air method will not be possible, so that for generators and other rotating machinery the cooling problem will be most difficult. Extraction of the heat from the generator may be effected by evaporative cooling or by the use of a fluid medium having appropriate thermal properties. In the case of evaporative cooling, if the vaporised coolant is discharged to atmosphere the equipment may be simple, but the weight of coolant required may become uneconomic on a long flight. If the vaporised coolant is condensed in a heat exchanger and recirculated, some other means of discharging the heat must be provided, necessitating the use of further equipment. The choice of systems must therefore depend on the function of the aircraft. Where a fluid medium is used to extract the heat a liquid is most suitable; an experimental liquid-cooled generator in which a liquid was passed through the armature shaft has been made. Future development of liquid cooling will, however, be aimed at passing the cooling medium through the stationary parts of the generator to avoid the difficulties of sealing rotating surfaces. A liquid-cooled generator of this type could be pressurised and difficulties with brush wear avoided.

After the extraction of heat from the generator, it is still, however, necessary to abstract the heat from the fluid and discharge it into some form of heat sink. One attractive method is to pass the cooling liquid through a heat exchanger in which the aircraft fuel is circulated on its way to the engine. It appears, however, that in some circumstances the amount of fuel available may not be sufficient (apart from other demands within the aircraft for the use of this medium) and some refrigeration equipment will therefore be necessary.

Further development of insulating materials for high temperatures will be needed. Organic insulants will not meet the extreme temperature ranges, and resort will have to be made to the glasses, metallic oxides and mica.

Design must also be concerned with arranging the equipment and its components to secure the best effect from the available natural cooling and to make the best use of any limited amount of refrigerated coolant which is available. It is probable that in order to economise in the cooling medium the items needing cooling will have to be grouped together in suitable enclosures and arranged so that the utmost effect is obtained from the available coolant. The lubrication of moving parts of equipment which are difficult to cool is another problem.

Altitude Effects.—The main effect of the reduction in air density with altitude is in the cooling of equipment. Above 35,000ft, the decrease in the density of the atmosphere considered as a cooling medium is not compensated by a temperature reduction; hence, above altitudes of this order, special consideration must be given to methods such as blast cooling in place of self-cooled equipment, greater air supply to blast-cooled machines or alternative cooling arrangements as discussed above.

The reduced atmospheric density at higher altitudes increases the difficulty of arc extinction, and the sealed relay, possibly filled with inert gas, may come into greater use for small-current circuits. For heavier current interruption devices, it is important to note that, with the increase of installed generating capacity, the use of compounding and interpoles in generator design, and particularly with the introduction of wide-speed-range generators, very large short circuit currents can occur. The wide-speed-range generator, designed to give full-load current at its lowest speed, could, at its maximum speed of 3·5 times the minimum, maintain normal voltage with much more than normal full-load current, and the short circuit current would be higher still. In practice, the short circuit current could be as much as five times the normal. The battery can also contribute to this fault current, and regeneration from rotating machines such as inverters will swell the total for a short time.

On an installation of four 22½kW, 112V generators and a 96V, 40Ah battery, a short

circuit current of about 7000A was estimated. For a large civil flying-boat with four 39kW generators, the estimated short circuit current was about 18,000A, and current-limiting resistors had to be inserted in the distribution circuits to limit the fault current to about 8000A to suit the state of development of the circuit breakers used in that installation. Further development of arc cooling and quenching devices and the use of series breaks will therefore be needed for circuit breakers on systems where very large fault currents can occur and which are used at very high altitudes.

Brush wear[3] may again become a problem as flight at greater altitudes for longer periods is attained. From laboratory tests, however, the latest treatment would appear to have a reasonable factor of safety. The brush wear problem would be eased by the adoption of an a.c. supply. Squirrel-cage motors have no brushes and with slip-ring machines the current-collection problem is easier than that on d.c. machines, since the brushes need not have the combination of properties required for sparkless commutation, but only those required of a current collector. A larger choice of materials is available for slip-rings than for commutators. Additionally, as it is usually the field current that has to be fed through the slip-ring, lower current densities can be used in brushes on slip-rings.

Reliability of Equipment.—The introduction of type tests under limiting climatic and other conditions has made some improvement in reliability, particularly under extreme climatic conditions. The process must, however, be extended to include life testing under conditions approximating more closely to those of the aircraft, including in particular vibration testing.

In addition to component reliability, greater attention must be given to the reliability of the electrical system of the aeroplane as a whole. Tests on the performance of the system will need the " mocking-up " of the complete system on the ground with the use of appropriate prime movers or oversize electric motors to drive the generators and with loads to simulate normal loading. The installation should resemble electrically, as closely as possible, that of the aircraft, with its cable sizes and lengths, protective gear, converting and utilisation equipment. Means to produce fault conditions must also be provided. Only in this way can the effect of faults in the system be adequately simulated and the influence of the individual components and their idiosyncrasies on the system be determined. Apart from the magnitude and effect of short circuits and the stability of the voltage regulators, the effect of over-voltages or under-voltages due to failures of voltage regulators can be studied. The transient effects due to load switching and fault clearance must also be considered ; such transients can be serious, for example, in radio equipment having components, such as condensers, which are normally operating near their maximum working voltage. The sharing of loads between the generators can be examined.

Tests of this nature will, it is considered, be an essential requirement for future aircraft electrical systems, and no installation should be cleared for use until all reasonable (and some apparently unreasonable) faults have been shown to be incapable of interrupting the supply seriously.

It has been possible to check a complete installation in this manner in the case of the electrical system for a large flying boat. The four generators, each of approximately 40kW, were driven by diesel engines through gearboxes. The experiments showed faults in the generator control gear, which, while they could be readily studied and rectified on the test rig, would have been extremely troublesome if they had not been discovered until flight trials were in progress.

In addition to coping with possible failures of the electrical equipment, it is now a necessity of aircraft design that sufficient electric power be provided for the minimum services necessary for flight and landing, even when all the engines have failed. For small aircraft having a low essential electrical load, an accumulator can be used, but for the larger aircraft this form of emergency supply is not economic. Various schemes for emergency supplies are being considered, such as small turbine drives to be started when the emergency arises, or windmill driven generators to be lowered into the slip stream, since insufficient emergency power can be obtained from windmilling the main engines.

Power Requirements in Future Aircraft.—Various estimates have been put forward from time to time of the maximum total electric power requirements of a large aircraft. Some of these have amounted to a figure as high as 700kVA. The larger estimates always include a generous allowance for complete electrical de-icing ; about 450kVA was included for this purpose in the one quoted. The use of electrical power for de-icing is attractive but inefficient, and has made little headway yet except for small surfaces such as windscreens and propeller blades, although heating elements for wing surfaces are being developed. The likely application of electrical surface de-icing will probably be limited to surfaces, e.g. the fin or tail, where the installation of appropriate heating ducts from the engine is difficult.

The progress of the present tendency to distribute power electrically rather than hydraulically for purposes such as powered flying controls and undercarriage operation will also affect the size of electrical installations, while the future radar requirements are a large factor.

It would be rash to be dogmatic in view of the undecided factors, but an estimate of about 160kW installed capacity for developments of the present generation of aircraft would appear reasonable, rising to 400kW installed capacity in the next generation of aircraft. Assuming four engines, unit capacities of between 40kW and 100kW will therefore be needed.

Obviously, such powers must be generated at higher voltages than the 28V of the conventional d.c. system. In this system the limiting size of unit is quickly being approached, and, while larger units are possible, the 12kW (400A) generator represents a reasonable maximum size. Where systems apparently require more than two such generators, investigation should be made of the economics of a higher-voltage system.

Form of Power Supply.—Constant-frequency alternating current has the advantages over direct current of using simpler motors of smaller size without brushes and of enhanced reliability, while the brush wear problems on alternators are much less severe than on d.c. generators. Voltages can be transformed with simple static equipment, and the usual rotating machinery for various direct voltages in radio equipment is not needed. Arc interruption is easier with alternating than with direct current. The inverters required for radar equipment, which forms an ever-increasing load, are unnecessary. For some time, however, until all radar equipments are built to work on the standard supply frequency, frequency changers will be needed.

Against these advantages some form of constant-speed drive is necessary, and this item offsets the saving in weight of the alternator, while a reserve source of supply to take the place of the battery has to be provided.

A three-phase, 208V, 400 c/s a.c. system with earthed neutral has been adopted as an international standard primary supply and is likely to be used in future large aircraft.

For small powers and in aircraft where low-voltage direct current is economic, the 28V system will probably continue, but the tendency to-day will be for a.c. systems to be used on relatively small aircraft having considerable radar loads, since by this means the heavy and inefficient inverters required on d.c. systems will be obviated and any d.c. requirements can be readily provided by rectification.

The advantages of constant-frequency alternating current with paralleled alternators have been appreciated for a considerable time, but the adoption of this form of supply has been held back by the lack of a reliable lightweight constant-speed drive capable of running alternators in parallel.

There are now several possible forms of constant-speed drive, such as :

(*a*) Hydro-mechanical from main engines.
(*b*) Air turbine.
(*c*) Gas turbine.

The hydro-mechanical drive consists essentially of a hydraulic motor and a hydraulic pump so arranged that the stroke of the pump can be varied by the governor to maintain a constant speed on the driven shaft. Paralleling is possible by the inclusion of load-sensitive circuits in the governor which produce a drooping characteristic on the speed/load curve. This form of gear has had considerable testing in service in the United States and now appears to have reached a reasonable state of reliability and performance.

Air and gas turbines are in the development stage. The air turbine uses compressed air from the main engine compressor and has the advantage compared with the gas turbine of easier installation and reduction of fire risk, but it is less economical in fuel consumption. Two forms of gas turbine are being investigated. In one form the air is tapped from the main engine compressor, as in the air turbine, but fuel is burnt in this air to provide greater output. In the other form the gas turbine has its own compressor and is, in effect, an independent unit. This latter form, although more complex and heavy, has the advantage that it will supply electrical power when the main engines have all failed.

Difficulties with parallel operation of air or gas turbines are forecast because of the relative " softness " of this drive, and it will be essential for their use in aircraft that these difficulties be overcome. The use of turbine drives of this nature will encourage the design of higher-speed alternators up to 24,000 r.p.m. The design of such alternators will raise new problems, particularly that of bearings, which will probably have to be supplied with oil from the turbine lubrication system.

Materials.—Reference has been made to the need for improved insulation for future equipment, and brief mention must be made of other improved materials which price considerations might rule out of commercial use.

For example, a large part of the weight of a generator is made up of the iron yoke, and improvements in the magnetic properties of this yoke would be valuable ; for aircraft use, expensive alloys can be considered which would be uneconomic for ground equipment. " Permandur," an iron-cobalt alloy, is one material of this kind. Although costing roughly £1 a pound its use, if satisfactory in other respects, would enable the weight of a generator to be reduced by 10 per cent and the subsequent operational economics would cover the increased material cost in a short time. A further example is titanium, an expensive material having an excellent strength/weight ratio, which should be considered in any application where its properties are suitable.

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Technical Reports

Barometric Changes and the Efflux of Gas in Mines. By C. S. Durst. Air Ministry Meteorological Office Professional Notes No. 117. London : H.M. Stationery Office, York House, Kingsway, W.C.2. Price 9d.—The publication states that a relation is obtained connecting the variation of atmospheric pressure and the efflux of methane in a coal mine. In one particular mine experiments were undertaken with the aid of which the constants in the relation have been determined. Information is given on the type of mine which is liable to suffer from efflux of methane due to sharp pressure falls. In the investigations experiments were undertaken in forecasting high emission of methane, and it was found that the forecasts from the Central Forecasting Office at Dunstable, were effective on 65 per cent of the occasions.

Plastics in the Tropics : 3.—*Amino Plastic Mouldings*. H.M. Stationery Office. Price 4s.—Previous reports in this series having covered Expanded Plastics and Polythene, the present describes tests on five batches of amino-plastic mouldings, exposed at various humid and one torrid site. All specimens lost their initial surface gloss when exposed out of doors and biological growths took place in a jungle clearing. Corrosion of brass inserts occurred, but without affecting the surrounding material. Changes in weights and dimensions occurred, in some cases accompanied by warping. All specimens lost impact strength, and those of Urea resin/woodflour filler, which were the most affected, also lacked electrical stability.

Floating Water-Purification Plant

IN THE ENGINEER of December 16th last we printed a description of a floating water purification plant for use in Iraq. This plant was a prototype ; an improved design has now been perfected for production and the first example of this improved version was recently tested on the River Weaver and subsequently shipped to Iraq. The prototype plant was manufactured by Marston Excelsior, Ltd., of Wolverhampton, from an outline design prepared by Mr. G. Smethurst, chief engineer of the Baghdad District Water Board ; the improved design has been evolved and manufactured by the same firm.

The reasons why a floating plant was called for were described quite fully in our previous article. Very briefly, however, it may be explained that each plant is intended to supply a village with water in an area where low-lying ground and swamp prevails and where river levels vary considerably up to as much as 40ft. There is thus appreciable advantage in concentrating the intake, purification plant and booster pumps in one compact floating unit. Furthermore, the various tanks are hydrostatically, almost balanced, and so theoretically, only thin membranes are needed to form them. The production plant is shown in the accompanying illustrations. Its size was chosen from consideration of a typical village in the area, and the design takes account particularly of cheapness, simplicity in operation, and of convenient dismantling for handling and shipping. The principal dimensions and data are listed in the table, from which it will be seen that the nominal rate of supply against an 80ft head is 1200 gallons an hour, but double that quantity can be obtained. A similar plant with half the output has also been designed.

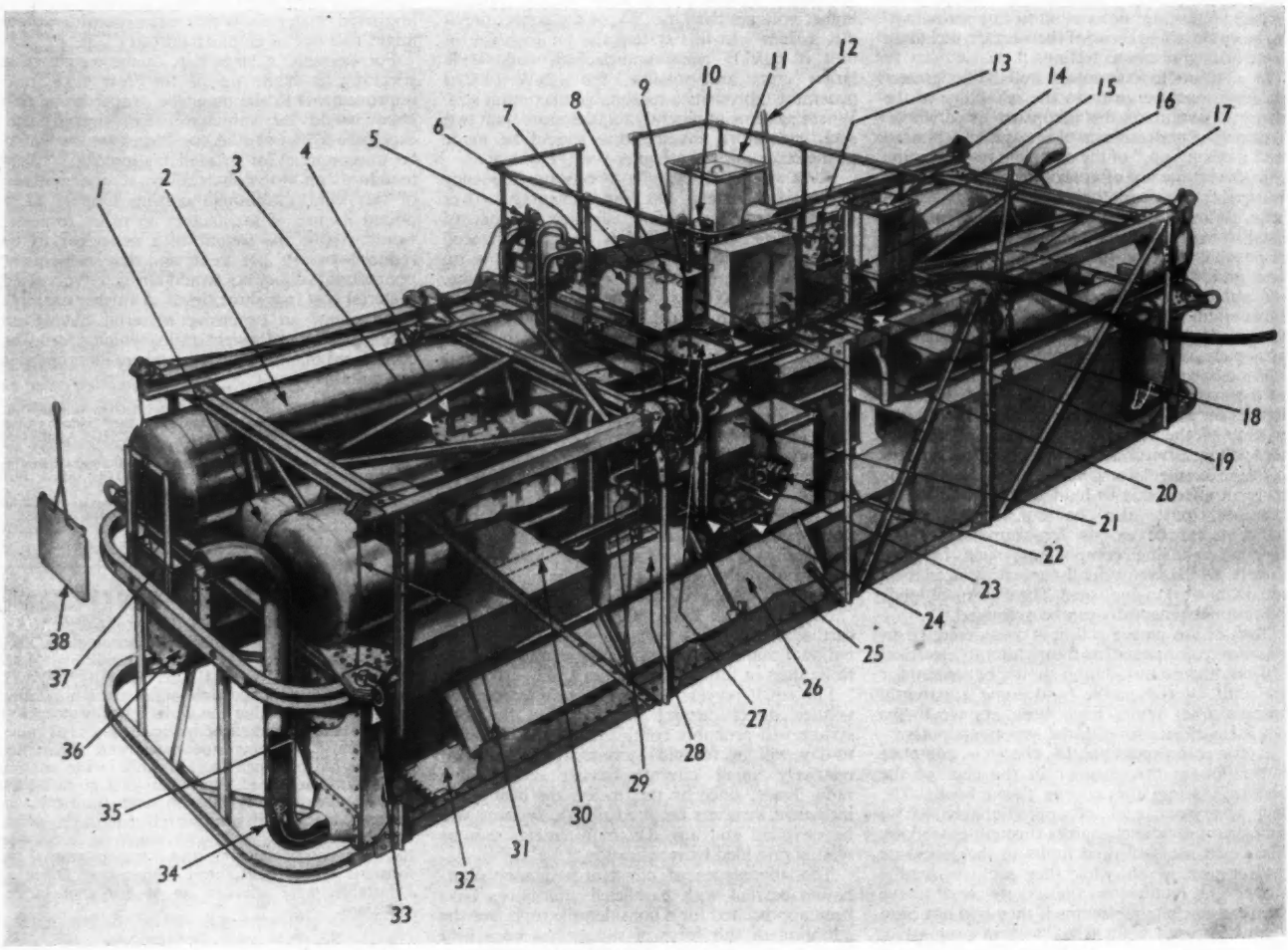
TABLE—*Leading Data for Floating Purification Plant.*

Overall length	38ft 8in
Overall width over flanges	9ft 6¾in
Overall height over handrails	12ft
Overall height for road transport (i.e. less handrails and ancillaries)	9ft
Draught :	
Minimum working draught	6ft 2in
Maximum working draught	6ft 11in
Weight of unit, including all ancillary equipment, excluding filter bed, estimated :	
Minimum	14,200 lb
Maximum	20,700 lb
Nominal water pressure	33 lb per square inch
Minimum	26 lb per square inch
Maximum	40 lb per square inch
Water pump output, nominal (each)	1200 gallons per hour against 80ft head
Chlorine dosing pump output (nominal)	2½ gallons per hour
Alum dosing pump output (nominal)	5 gallons per hour
Useful storage in booster tanks	200 gallons

OPERATION

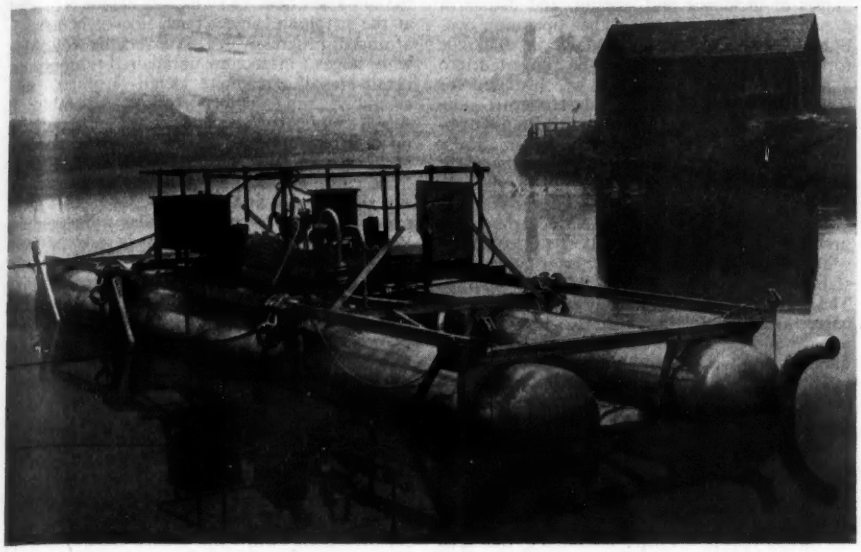
The principal tanks, pumps, and so forth are shown in the illustrations. The flow of water through the plant is as follows :—The intake is on the downstream side of one of the sedimentation tanks ; it is screened and is 1ft 9in by 1ft 9in in size. Water flows through it and along the entire length of both tanks at a velocity not exceeding 3·25in per minute ; alum is injected close to the intake to assist in settling out grit and coarse solids as the water passes through the two tanks. It then flows into the filter tank, a rectangular tank in the centre of the plant with a sand filter, operated as a rapid gravity filter. The filter drains into the purified water tank, which is built round it.

Up to this point the flow is by gravity and is controlled by the water level in the purified water tank. There are pump intakes in this tank, from which water is pumped into the two booster tanks. These two tanks are kept about one-third full of water, with compressed air above, and are directly connected through a valve to the main supply, the pressure in the booster tanks being sufficient to overcome the mains head. Storage in the booster tanks is equivalent to the full rated supply for a period of ten minutes. Chlorine is introduced into the purified water



1—Booster tanks.
2—Buoyancy tanks.
3—Manhole to booster tank.
4—Pressure relief valves.
5—Air compressor.
6—Control valve—filter bed wash water.
7—Control valve—filter bed to purified water tank.
8—Control valve—sedimentation tank to filter bed.
9—Control valve—isolating booster tank.
10—Alum dosing pump.
11—Alum solution container.
12—Operating lever for sedimentation tank cleaning flap.
13—Water pumps.
14—Chlorine solution container.
15—Control valve—mains outlet.
16—Chlorine dosing pump.
17—Transfer pipe—sedimentation tanks.
18—Control valve—wash water connection.
19—Automatic switchgear.
20—Mains switch—electric—and compressor operating switch.
21—Filter bed.
22—Control valve—filling and emptying.
23—Collector pipes—filtered water.
24—Air disturbance pipes—filter bed.
25—Air lift—filter bed.
26—Cleaning flap—down position for cleaning, up position for normal operation.
27—Manhole to filter bed.
28—Purified water tank.
29—Slinging and mooring shackles.
30—Transfer pipe—sedimentation tank to filter bed.
31—Operating rope for scraper.
32—Scraper for disturbing settled silt.
33—Mooring shackles.
34—Air lift—sedimentation tank.
35—Manhole to sedimentation tank.
36—Sedimentation tanks.
37—River water inlet.
38—Baffle plate—filling and emptying.

General layout of floating water purification and pumping plant



Floating water purification plant on test on the River Weaver, prior to shipment to Iraq

tank, the quantities handled being sufficiently small for mixing to be adequate.

Operation of the pumps is controlled by a pressure switch, actuated by the compressed air in the booster tanks. When the pressure falls below a given figure, due to consumption through the main, one of the pumps is brought into use ; a further given drop in pressure brings the second pump into use, and subsequent rise in pressure successively cuts them out again. Operation of the pumps draws down the level in the purified water tank, thus inducing flow through the filter and hence into the sedimentation tanks ; at the same time operation of the pumps also initiates the injection of doses of chlorine in the purified water tank and of alum, for flocculation, in the first sedimentation tank.

The main control valves and mechanical plant, all of which are concentrated on the platform of the unit, are generally of standard construction, consisting of a compressor, two pumps, chlorine and alum dosing equipment, and electrical pressure switch, control box, and so on, as described in our previous article. The only major change from the prototype has been the substitution of self-priming pumps in place of the orthodox centrifugal type and foot valve.

In cases where there is no local electricity supply, provision will be made for mounting a diesel-engine-driven generator on the platform. The generator can then be installed, if local conditions require, with capacity to spare for local lighting.

The plant is automatic in operation and will normally need a brief inspection daily for checking the water level in the booster tanks and cleaning the sedimentation tanks and filter. A small pressure relief pipe, controlled by a cock, leads from one of the booster tanks, which it joins at the correct operating water level. When the cock is opened air is blown out if the level is too low, and vice versa, so the correct level is achieved when a mixture of air and water escapes.

The filter bed is cleaned by the method normally employed for rapid gravity filters, with an upward flow of air and water. Dirty water resulting from the cleaning process is removed by an air lift, using compressed air from the booster tanks. No filter controls are necessary because the rate of filtration is controlled by the water level in the purified water tank.

The sedimentation tanks show one of the major changes in design from the prototype plant. Cleaning out the settled sludge had previously been difficult, so the tanks of the production model, which each extend for the full length of the unit, are shaped with a relatively narrow gully, along the bottom, into which the sludge settles. For cleaning, a hinged flap, normally positioned against the side wall, is lowered by manually operated levers, thus effectively isolating the gully, except for an inlet space at one end and an outlet space at the other. The latter connects with an air lift, which induces a flow of about 23ft per minute through the gully. So, to clean out the settled sludge, the flap is lowered, the air lift started, and the sludge is loosened by a scraper, manually operated by an endless rope which passes over the platform of the plant.

Construction

The principal tanks of the floating water purification plant are of welded aluminium alloy construction. Generally six-gauge sheet is used, the strength criterion being handling stresses, and the alloy is N.S. 5 (B.S. 1470). Thinner sheet may be used on subsequent plants, except for the lower parts of the sedimentation tanks. Assembly is on a bolted frame of structural steel, which is protected from corrosion by zinc and aluminium coatings and bituminous paint.

When assembling, the central tank—a composite welded construction comprising the filter bed with the purified water around it—is lowered into position on to the steel base frame. This tank extends to the full depth of the plant. The sedimentation tanks are also assembled by bolting (all the other tanks are completed and assembled in the works) and the steel side frames are then bolted to the sheets forming the contiguous sides of the sedimentation tanks, and the tanks are then formed by bolting on the other sheets.

The two buoyancy tanks are next fitted, one above each sedimentation tank. These tanks also extend the full length of the plant and have two purposes. First, they give sufficient buoyancy to keep the plant afloat if all the other tanks are completely flooded. And second, they give torsional rigidity to the structural frame of the plant. They are cylindrical tanks and in manufacture a stiffening ring is welded in at each transverse joint in the tank.

With the buoyancy tanks in position the shorter booster tanks can then be placed at each end and the steel frame completed by adding the top transverse members (which incorporate collars mating with the buoyancy tanks) and by the diagonal bracing holding the booster tanks.

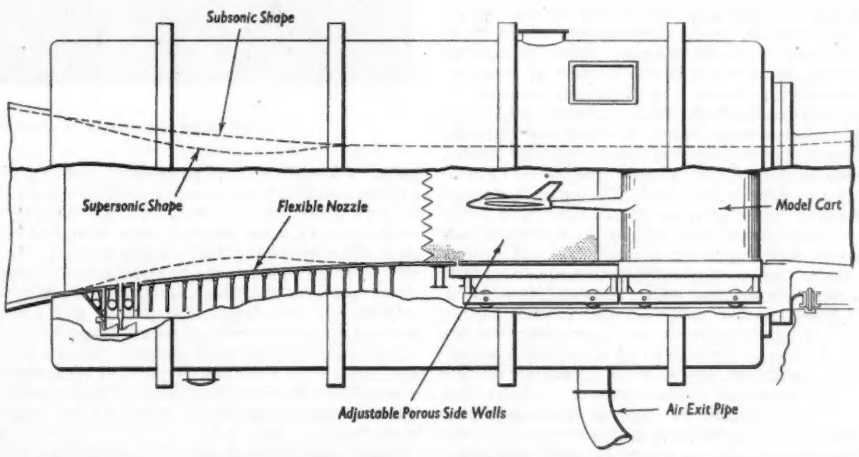
When all the tanks are empty the sedimentation tanks have an " outrigger " effect, which keeps the plant stable. For filling the tanks at this stage, or for completely emptying them for towing (a distinct possibility for some of the semi-nomadic villages in Iraq) or for dismantling, independent pumps are needed, but in future construction it is intended to make the plant completely self-contained under these conditions.

Transonic Wind Tunnel

ON Friday last, H.R.H. the Duke of Edinburgh formally started the large transonic wind tunnel built by the Aircraft Research Association, Ltd., at Bedford. Before doing so he observed that it was an illusion to believe that problems were solved by " science " or by more advanced machines : the solution was found by the designer of the machine. He digressed to observe that the aircraft industry could not be held wholly to blame for any shortcomings of its products : the Minister of Supply might also be responsible for what went wrong.

When the tunnel was running, closed circuit television was used to show those present the way in which it was controlled and to observe a model, carrying tufts, in the working section.

A general description of the tunnel appeared in our issue of February 5, 1954, page 205 ; however, at that time it was not possible to describe the design of a working section to allow testing at speeds close to that of sound. As long ago as 1940, Sir Geoffrey Taylor observed that since the contraction coefficient of an open-jet wind tunnel was negative and that of a closed tunnel positive, it should be possible to define the working section by slats and slots, so obtaining a contraction coefficient of zero ; thus there need be no section at which the speed was inevitably Mach 1. Such slotted tunnels were in use in the U.S.A. as early as 1947, and their achievements in transonic wind tunnel technique led to the widely publicised " Area Rule " concerning the drag of bodies at the speed of sound. While the porous wall is incorporated to



Nozzle and working section of transonic wind tunnel

allow transonic operation in the tunnel, it also greatly influences the size of model that can be used. The model must not intercept any shock waves reflected from the walls, if free flight conditions are to be simulated : since the wave will be reflected as a compression from a slat and a rarefaction from a slot, the reflection will tend to be imperceptible at a distance from a slotted wall. This condition, however, can only be achieved for the appropriate air flow through the porous wall, and since this flow will be different for the various waves impinging on the wall, only a partial relaxation of the restriction on model size can be expected. The reflected wave is considered to die away closer to a perforated wall than a slotted one, and the 9ft by 8ft working section of this tunnel is bounded by steel plates pierced regularly with holes, the porosity appearing to be about 25 per cent ; the accompanying illustration shows this. It is expected that

Sting-mounted model in the perforated working section: as a strut in the foreground is raised and lowered, a simple linkage decreases and increases the model incidence through the range—10 to 22 degrees about a horizontal axis

models up to 6ft long will be tested : the side walls can be flexed about 1 deg. to vary the proportion of bleed. It is interesting to note that the perforations are ½in holes, and the television camera views through one of them.

The nozzle upstream of the working section has flexible top and bottom boundaries, which can be set by a cam to nine different configurations, the first appropriate for speeds up to $M=1$ and the others ranging from $M=1{\cdot}15$ to $M=1{\cdot}6$, it being expected that the present maximum of 1·3 will be increased by development in the future. A model of the working section was built by Fairey Aviation, Ltd., and tested in a wind tunnel at the Royal Aircraft Establishment, while a model of the cooler section was both built and tested by the former.

It is intended that the 13,750 h.p. eleven-stage Brown Boveri compressor used to return the working section bleed air to the circuit, which has a design pressure ratio of 3·2, will, within the next twelve months, be incorporated also into a supersonic tunnel with a section 2¼ft wide by 2½ft high and a working range from $1{\cdot}6M$ to $3{\cdot}4\ M$. In addition, a second transonic tunnel, 9in by 8in, will be run as an intermittent tunnel from the dry air supply of the supersonic tunnel.

As mentioned in our earlier article, the laborious process of manual recording and reduction of results is not suitable for this tunnel, and, while continuous visual indication of the forces on the model is provided, strain gauge readings of air loads, readings of the angles of incidence and sideslip, and details of pressure, temperature and other operating conditions will be recorded, usually in analogue form. These details will then be converted into a digital notation, stored and synchronised for feeding a remotely controlled Hollerith gang punch. At the same time, some constants associated with the run will also be automatically recorded in the card. From these calculations it will be possible to convert the tunnel pressures into Mach number, and the strain gauge readings into forces and moments on the model, and then proceed to a non-dimensional coefficient form suitable for analysing the performance and stability of a corresponding full-scale aircraft. The calculations will include the making of corrections for factors such as tunnel interference and the deflection of the model support under the applied loads.

The Hec 2M digital electronic computer which collates this material uses, as a main store, a magnetic drum on which are stored those numbers relating to a problem and the operating instructions which the machine must carry out to arrive at the final solutions. Information is fed into the machine on Hollerith punched cards and results are automatically punched by the machine in further cards. Cards containing the final results will be interpreted by an automatic card-operated typewriter, constructed by the Aircraft Research Association, using a Hollerith serial card reader.

Railway Diesel Engine Repair Shop

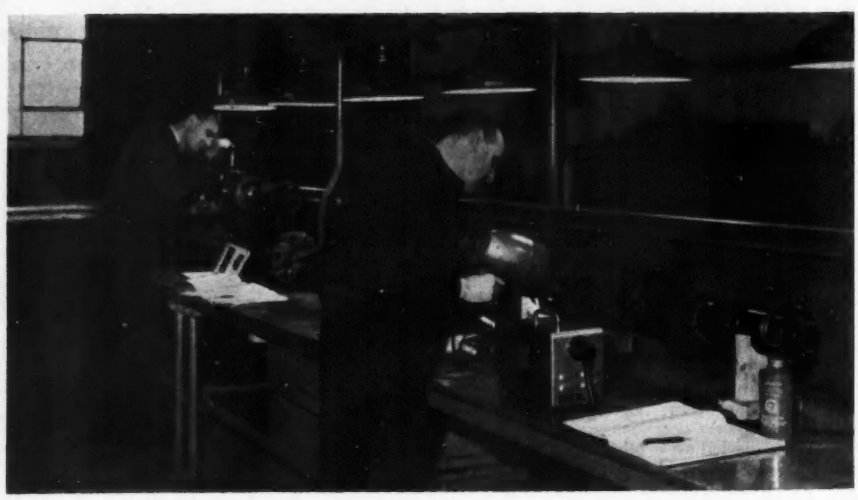
A NEW workshop has been established at the Derby locomotive works of the London Midland Region of British Railways, for the repair of the horizontal diesel engines used in railcars. This workshop is situated in a reconditioned and modernised shop which was previously used for locomotive tender tank repair work, and it is designed to handle up to thirty engines a week. The shop has a floor 186ft long by 47ft wide, with an adjoining 30ft by 47ft section laid out for engine stripping.

The engine stripping section is equipped with a twin-chamber, high pressure spray washing plant, which is used for the external cleaning of engines and their sub-assemblies. Three steam-heated boshes are also installed for the cleaning, washing and carbon removal from components after the engines are fully stripped down. In this cleaning section the engines are stripped down into the following eight sub-assemblies : cylinder blocks, crankshafts, pistons and connecting rods, oil pumps, cylinder heads, crankcases, water pumps, and manifold covers and auxiliaries. All the relevant parts of these sub-assemblies and their attendant details are loaded into separate crates for transfer to the main workshop.

Eight series of benches are arranged down the length of the main shop in pairs, and each series of benches is fully equipped to deal with one of the sub-assemblies into which an engine is divided at the stripping stage. Each line of benches is arranged progressively to cover the following work stages : inspection, unrepaired components, detail repair, repaired detail storage, sub-assembly, sub-assembly storage, assembly of sub-assemblies to the cylinder block, and building up of a reconditioned engine. For the purpose of housing details between stages special racks fitted with inclined trays have been provided so that each line of benches and racks can be utilised for one particular sub-assembly. When each crate of components is received from the stripping section at the end of the appropriate bench line details are examined visually for fractures by ultra-violet-ray apparatus, crankshafts and connecting rods being checked on a magnetic crack detector, and all items are then checked dimensionally to determine whether or not they are repairable. The crankshaft inspection section is shown in the illustration on this page. After examination, components requiring repair are placed on the unrepaired detail racks and from there they are withdrawn for repairs either to the detail benches within the shop or, as necessary, for repair in one of the other workshops. These components, after repair, along with the items determined at examination as not requiring to be repaired, are passed on to a repaired detail stores set across the centre of the shop.

From the accumulated stock of components in the repaired detail stores the sub-assemblies are made up and then transferred to sub-assembly storage racks at the end of appropriate lines in readiness for final assembly. For the final assembly, a series of portable erecting stands are arranged across the extreme ends of the sub-assembly lines. Erection is performed in four stages, each stand and unit being moved in successive stages to the end of each pair of lines for the respective sub-assemblies to be erected. On completion, the engine is taken off its stand for testing and the empty stand is returned to the first stage of the line.

For final engine testing purposes Heenan and Froude hydraulic dynamometers are being provided. The first plant which has been installed is suitable for testing engines up to 650 h.p. at any speed ranging between 1400 r.p.m. and 1500 r.p.m. It is fitted with a shaft extension at the rear end and to this a 35 h.p., 300 r.p.m. to 800 r.p.m. variable speed motor has been fitted for starting and free running of the engines. A 100 gallon capacity water tank fitted with a Drayton regulator, provides for the automatic control of the temperatures of the cooling water and engine oil. The supply of fuel is from 400-gallon tank and is equipped with a " Flowrator " meter which measures fuel consumption in cubic centimetres per second. Final inspection is carried out, and during the testing of the engines the finished work inspector is responsible for seeing that the engines attain the necessary performance figures, which are then recorded.



Initial inspection section of crankshaft line of diesel engine repair shop

Some Problems in the Maintenance of Nuclear Reactors

By H. G. DAVEY, O.B.E. M.Sc.*

An extract is printed here from a paper presented before the Institution of Chemical Engineers on May 3rd in conjunction with the British Nuclear Energy Conference. When the Windscale reactors were being designed it was assumed that after they went on to power those parts which had been subjected to radiation could not be maintained. Therefore, a fundamental concept of design was, as far as possible, to make the reactor itself static and to keep moving parts outside the biological shield. Over a period of time those items contained within the ractor proper and subjected to the influence and effect of flux, temperature, and air flow developed faults and, therefore, unusual and to some extent unexpected maintenance work has had to be done under reactor conditions. The paper gives examples of the work done, the techniques evolved for doing the work and the precautions taken to ensure that the personnel engaged on this work did not receive radiation doses in excess of the limits laid down by the Medical Research Council. After five years' operating experience the author is satisfied that a reactor can be a maintainable unit. This will have a fundamental effect on the design of future reactors.

THE Windscale reactors are graphite moderated and air cooled. When design studies for the Windscale reactors (Fig. 1) were undertaken there was little practical knowledge, and even less experience, to draw upon, but all available evidence indicated that after the reactor went into operation radiation and induced radioactivity would make the core of the reactor and its immediate vicinity inaccessible. Therefore, a basic design principle was to locate engineering equipment outside the biological shield and if this could not be achieved absolutely, equipment inside the shield should be stationary or have a long life without requiring maintenance. A corollary to this was that means of access through graphite lattice into trucks or skips located in the water duct. While the reactor is operating a train of skips is always in position and immediately after a scheduled shut-down the train is withdrawn and the skips are inspected. This rule was introduced to check on the blowing out of cartridges during normal operation.

During such an inspection in reactor No. 2 in May, 1955, a scanner guide shoe bracket with four holding bolts, sheared and still in position, was found in a skip. The shoe itself had been sheared off where the 2in diameter pin entered the bracket and the shoe was missing. This was a discovery of great significance and with potentially very serious consequences.

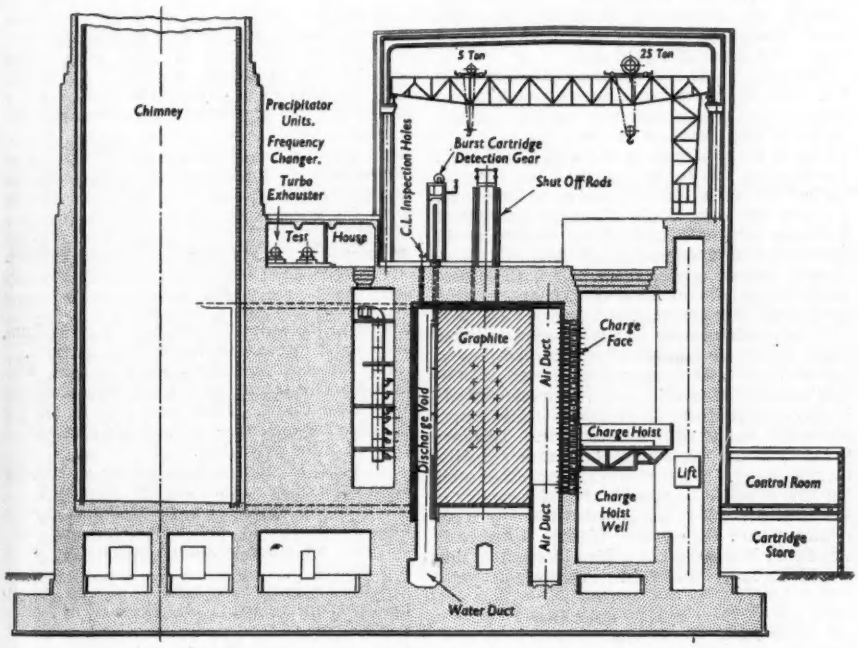


Fig. 1

the shield would not be provided and experimental and inspection holes in the roof of the biological shield would be kept small to minimise radiation leakage.

The outstanding exception to the rule that moving equipment should be outside the biological shield is the burst cartridge detection gear. This is a substantial stainless steel structure which moves vertically up and down the back face of the graphite lattice inside the biological shield.

Direct Work with Temporary Shielding

When cartridges are discharged from a reactor they fall vertically from the back face of the

The sluice gates separating the water duct from the storage pond was put in position, extension pipes were fitted to the pump suctions, and the water level in the duct was pumped down to 8in. A quick inspection confirmed that the right-hand bracket of No. 7 scanner was missing and that the guide rail bolted to the scanner had broken loose ; the remainder of the brackets and guide rails were in position. At the same time, a radiation survey was carried out and the general level near the floor of the water duct was 80 r/8 hours.

The matter was serious because of the function of the burst cartridge detection gear. This gear, which consists essentially of eight scanners (see Fig. 2), is vital to the reactor operation. It gives an early indication of a cartridge failure and thus enables the faulty cartridge to be discharged before the burst can develop to a point where radioactive contamination of the back of the reactor might occur. Remedial action was, therefore, imperative.

It was recognised that replacing the original bracket and tightening the guide rail was out of the question since they were located in a field of high radiation intensity. A suggestion was made that some form of roller, bearing on the back of the aerofoil section of the scanner frame, should be fixed to a long arm and the lower end of the arm be bolted to the wall of the water duct by a diver. The suggestion was accepted in principle, but it was agreed that the work could not be done by a diver. Ultimately, an initial plan was evolved for prefabricating rollers on a frame and installing this frame by working in the dry duct under temporary shielding. Approximate dose rates at various points were obtained quickly and estimates of the thickness of shielding required for the protection of personnel were made. It was also laid down as a cardinal principle of the operation that each man's radiation dose would be limited to 0·6 r (i.e. two weekly m.p.l.s). With this information and direction, the engineers were enabled to start detailed planning.

It has been mentioned that the general level of radiation in the duct under the discharge face was 80 r/8 hours, but this fell rapidly on moving away from the face. At the access hole to the duct from the West Rear Court—Fig. 3—it was 2 r/8 hours and 20 yards further along the level had dropped to approximately 1 r/8 hours. Using these figures, three areas were defined.

Waiting Area.—This extended from the storage pond sluice gate to within 20 yards of the West Rear-Court access point. All mechanical equipment needed for the operation was marshalled in this area. Personnel also assembled here or outside the duct at a place convenient to the access point.

Entry Area.—The part of the duct immediately below the access point. General supervision was carried out from here.

Operation Area.—This comprised that part of the duct under the discharge face and adjacent to it.

Investigations into plate sizes and handling problems showed that it would be possible to suspend a plate 2in thick by approximately 16ft by 5ft wide from the outer roof inspection hole using the reactor crane already installed. An end shield could also be suspended from the inner west inspection hole and dropped into position so that the lower end rested on the floor of the duct whilst the upper end leaned against the roof shield, thus forming, with the sides of the duct and the end wall of the discharge area, a box inside which work could be done. Because the inspection holes in the roof are only 13in away from the rear wall of the duct, the top shield, if suspended centrally would tend to swing underneath the duct overhanging rear wall and would have to be dragged up the rear wall. For this reason the centre of gravity of the top shield plate was moved over to the rear as far as possible. The roof shield could be propped from below, leaving the crane free. As the minimum height of the roof shield above the floor level would be about 16ft, some additional shielding along the front and rear walls of the water duct and the end wall of the discharge area would be necessary to cover the lower additional thermal shield plates. It was realised that it would be preferable to lift up the roof and both front and rear shield plates in one lift, but considerations of weight and balancing made this impossible. The shields were to be moved into the duct to a position convenient for lifting on two existing trucks which were available in the plant store. These two trucks were originally built to facilitate removal of a complete scanner frame in the event of failure of any part of the mechanism.

The main shielding plate was 2in thick and was stiffened by two 8in by 3in R.S.C.s running longitudinally and four 8in by 3in R.S.C.s running transversely. The two longitudinal R.S.C.s had two large lifting lugs welded between them on which the main weight was taken. The third lifting lug was merely to provide additional stability and to ensure a perfectly level lift. The shield was provided with two openings to give access to scanners seven and five. The openings, which were 20in by 5ft 3in, were fitted with doors

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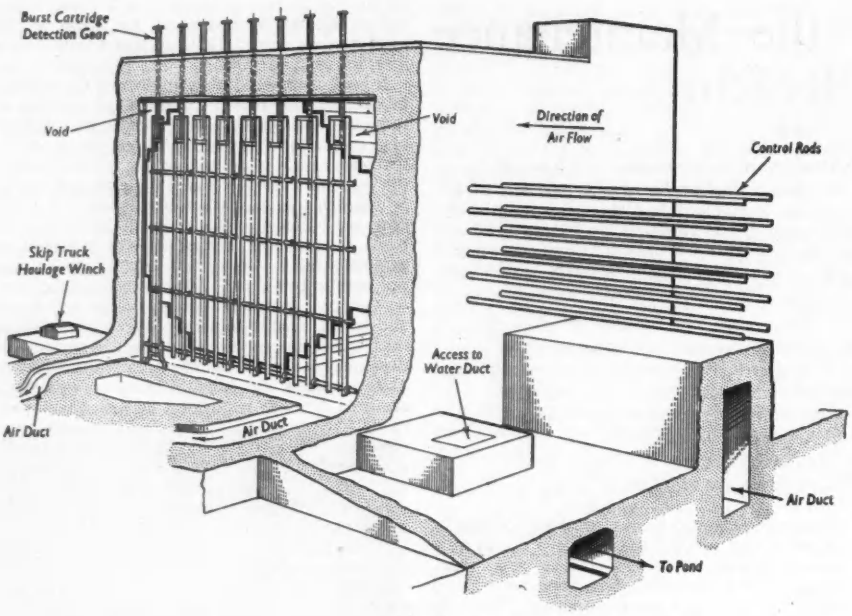

Fig. 2

rolling on ball-bearing wheels. The tank, which was added as a modification, was formed by putting a false bottom over the main plate under which the doors could move, and welding on side and end plates to give a depth of water of 12in. The doors were secured from below by means of a screwed locking pin, and stops were welded to the front edge of the main plate to prevent the door from running out too far. The tank emptying valves were not positioned in the best place, and it was intended to move them before commencing the operation so that they could be operated from below the shield. This, however, was not done as there was insufficient time and, in fact, it proved unnecessary.

Shielding was required at the front and rear to protect personnel from radiation emanating from the lower thermal shield plates. These shields were made from 1in thick plates, and those at the rear were bolted to the top shield. Skids were also bolted to the top shield between the rear shield plates. These were necessary to ensure that the complete unit rode smoothly over obstructions on the rear wall when the unit was lifted inside the water duct. The total weight of the top, front, and rear shield plates was 4 tons 15 cwts.

The front shielding for the lower thermal shield plates was made up of two 1in plates, 6½ft by 4ft and one plate 21in by 4ft. The end shield plate was a 1in plate 5ft 3in by 4ft. These plates were all provided with two pairs of ¼in eye-bolts on the side, and a pair of eye-bolts in the top edge. The intention was to suspend these plates from the front edge of the roof shield when it was in position. The pair of side eye-bolts was, therefore, provided to enable the plate to be lifted by means of two sets of ½-ton blocks suspended from eye-bolts in the top shield plate, and the second pair was provided to enable turnbuckles to be attached to suspend the plates permanently from the roof shield. The eye-bolts in the top edge were to enable an alternative lifting arrangement using a winch rope passing through the scanner roof hole, if this arrangement proved to be possible.

The end shield consisted of 2in M.S. plate and 1in M.S. plate welded to two 8in by 3in R.S.C.s. The R.S.C.s were welded off centre in order to shift the centre of gravity of the shield over towards the suspension point and to lessen the tendency of the plate to hang at an awkward angle when lifted inside the duct.

The roller guide bracket consisted of two 4in S.S. tubes shaped and braced to form a frame carrying two shaped rollers at the top end and provided with brackets at the bottom end to enable it to be bolted to the water duct wall. The bracket was to be bolted to the concrete wall of the water duct by means of Rawlbolts. As there was some doubt about the strength of the fixing bolts used for the lower thermal shield plates it was decided that where the guide fixing bracket butted against these plates, the plates would be cut to allow Rawlbolts to be taken right through into the concrete.

From previous experience it was expected that there would be no difficulty in drilling satisfactory holes in the concrete wall, provided the hole was clear of reinforcement. If reinforcement is encountered there is usually no satisfactory alternative but to drill another hole. To allow for this, all the fixing brackets were bored with four 2in holes. It was assumed that within each 2in hole it would be possible to find room for a ¼in Rawlbolt hole to be drilled without striking reinforcement. In any case, if three out of each set of four holes could be drilled successfully this would be acceptable. The ¼in Rawlbolts were fixed with special large S.S. washer plates to cover the 2in holes.

The rollers were made from phosphor bronze and were mounted on 2in diameter S.S. pins bolted through solid 4in S.S. machined blocks welded to the top end of the 4in S.S. tubes. The pins were secured by 1¼in B.S.W. S.S. nuts locked by ¼in diameter S.S. taper pins. The roller profile was determined by the necessity to restrain sideway movement of the scanner frame even when, the in absence of air pressure, it fell back towards the graphite face the maximum possible distance (1½in).

In the early stages of planning, it was realised that good communications would be essential, since in order to do the job in the duct, equipment would be used on the reactor roof in the West Rear Court and at the winch end of the water duct. Three types of communications were set up :

(*a*) Frogmen's intercommunication sets positioned on the reactor roof, in the water duct and at the winch house. These proved very satisfactory and enabled the supervisor in charge in the water duct to call for effort from, and to give instructions to, the other stations.

(*b*) Standard intercommunication sets positioned on the reactor roof in the water duct and West Rear Court. These were used mainly for directing the movement of men and materials in and out of the water duct.

(*c*) Field telephones were set up as standby in case the other methods failed to operate.

The shielding and the roller guide bracket were fabricated in the workshops and concurrently all other necessary preparatory work was done.

A briefing lecture was given to all who were to take part in the work, and during this lecture every aspect of the job was discussed in detail ; the radiation hazard was stated clearly and the plan was described which had been evolved to ensure that no man would receive an overdose.

It was decided to carry out erection trials. All relevant equipment was delivered to the forecourt of Reactor No. 2. The top and rear side plates were lifted to the correct height and propped against the air duct ; 10in "Acrow" props were inserted and braced and tested to carry the weight. It was realised that these props would have to be positioned in the water duct without the end and side shields in position and, therefore, speed and efficiency would be necessary. The operation was practised several times and a detailed drill produced for the team of scaffolders. The working platform under the roof shield was also made up and tested to ensure that the erection time in the duct was reduced to the minimum.

Figs. 4 and 5 show the missing bearing, the

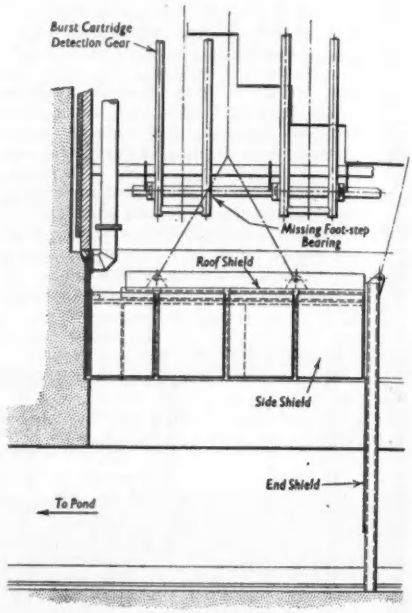

Fig. 4

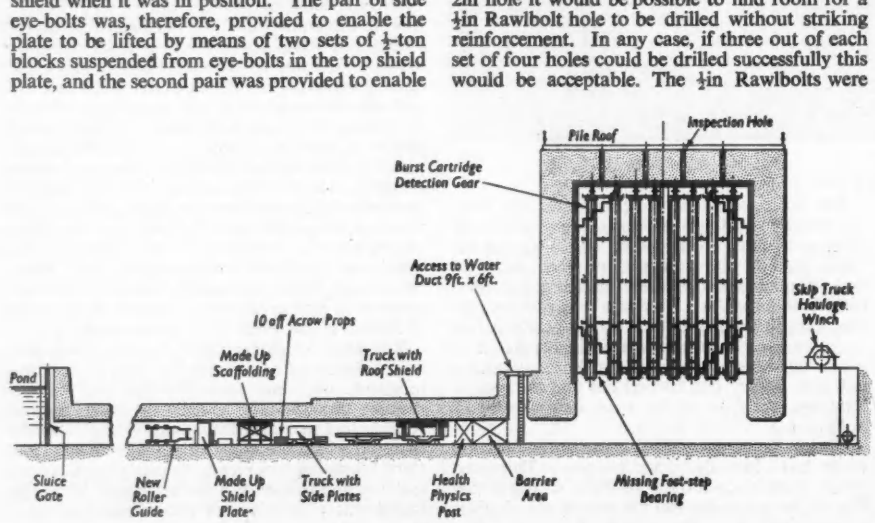

Fig. 3

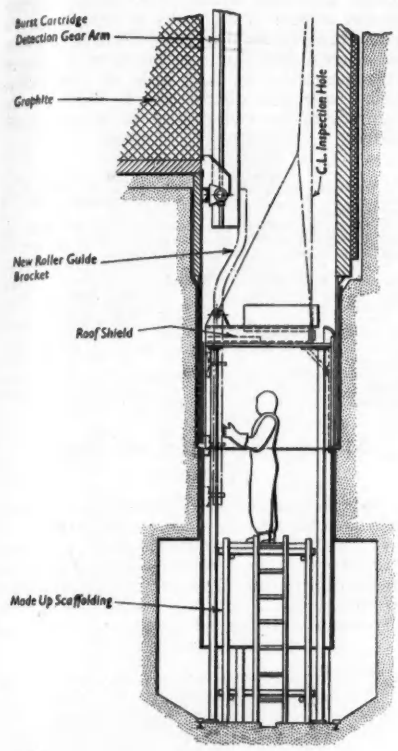

Fig. 5

position of the shielding, and the working platform under the roof shield. Fig. 3 gives a general indication of how the job was organised and carried out. The only unexpected difficulty was in the erection of the roller guide bracket. This was due to the awkward shape and size of the bracket and the restriction to movement imposed by the shield props and bracing. The bracket had to be dragged along the duct wall in a horizontal position and lifted by means of a winch rope into a vertical position. It was then hoisted and bolts put in at the bottom. The front shield plate had to be removed to allow the top fixing bolts to be located and here difficulty was experienced. The bracket was unbolted, the front shield plate lowered to the floor of the duct and the bracket refixed. An attempt was made to drill the eight holes at the top of the bracket, but because of the unforeseen irregularity in the concrete facing behind the lower thermal shield plates the drilling was unsatisfactory.

It was then decided to fix a rigid M.S. backing plate against the thermal shield plate with four ¾in Rawlbolts located between the two arms of the roller guide bracket. After final adjustments had been made and the alignment of the bracket was satisfactory the plate on each arm of the bracket was welded to the fixed plate.

After fixing was complete the roof shield doors were opened and the scanners were wound down by hand. It was not possible to do this completely because scanner No. 3 fouled the top of the roof shield, but the test was sufficient to prove that the bearing was accurately installed and fulfilling its function.

A health physics post was set up in the water duct and, in effect, this was the line of demarcation between the waiting area and the working area. From this post, health physics control was exercised and every man proceeding to the job had his time of entry recorded and was told how many minutes he could stay on the job. It has already been stated that in planning it was decided to limit each man's exposure to 0·6 r (two weekly m.p.l.s) and that, including supervisors, no one employed on the operation should exceed an integrated dose of 3·9 r (thirteen weekly m.p.l.s) in the thirteen-week period up to and including the time of the operation. Because of the time limit imposed on each individual, 251 people were involved in the operation. The control of radiation exposure was successful.

Control of Thomas Process by Temperature and Spectral Measurements

By F. WEVER,* W. KOCH,* H. KNUPPEL,† K. E. MAYER† and G. WIETHOFF.†

For the control of the Thomas process a radiation pyrometer for taking temperature measurements, and a recording flame spectrometer for checking the course of the reaction, have been developed. Taking both these measurements together, one can maintain reliably the uniform composition of the metal, by allowing the converter to be tilted in time and avoiding all over-blowing.

IN Siemens-Martin and electric arc steel production, the continuous control of the metallurgical processes by means of chemical analysis and by measurement of the temperature of the liquid metal, is to-day general practice, and is a pre-requisite for keeping working conditions constant and thus ensuring a high quality of the product.

In the Thomas process the situation is different. The "blow" takes such a short time that control by chemical analysis and by temperature measurements with immersion thermometers, is impossible. Consequently, it has been more difficult to produce steels of constant quality by the Thomas process than by other methods.

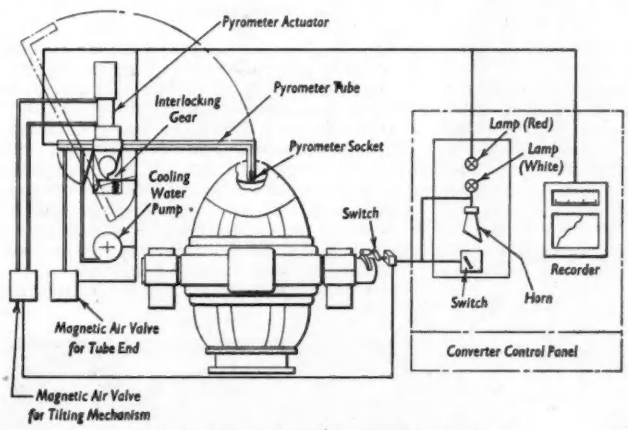

Fig. 1—Temperature measurement (schematic)

In co-operation between the Max-Planck-Institute for Iron Research and the Dortmund-Hörder-Hüttenunion, an installation for taking temperature measurements was developed which allows continuous readings to be recorded during the blowing of the converter. This research has been described in detail,[1] while previous work upon which it is based is given.[2] For this purpose, use is made of a total radiation pyrometer, consisting of a photo-electric cell, which is introduced through the throat of the converter. The cell is housed in the end of a water-cooled tube which is bent through a right angle, so that it can be rotated about a horizontal axis at one end until the free end is below the combustion zone inside the converter. The tube mouth (Fig. 1) is kept free from slag and dust by means of compressed air. The movement of the measuring tube is done hydraulically and controlled from the converter control stand. Movement of tube and converter are interlocked by solenoid-operated air valves, so that the converter cannot be tilted before the tube has been withdrawn.

A temperature-time curve is shown in Fig. 2. After being placed in position, the cell requires about fifteen seconds to reach thermal equilibrium. The small temperature fluctuations of about 5 deg. Cent. are connected with the movements and temperature variations in the melt. Statistical evaluation showed the accuracy of the measurements to be better than ±10 deg. Cent.

When oxygen-enriched blast is being used, the temperature measurements have to be corrected slightly, the correction being proportional to the smoke density. This is carried out automatically by means of the spectrometer which will be described below.

The full value of measuring the temperature during the blow is only obtained when combined with measurements of the metallurgical changes by observing the converter flame.[3] The converter flame emits simultaneously the spectral lines of a number of elements, band spectra of various compounds, and a continuous spectrum.[4] By selecting with a spectrometer those components which are most useful for controlling the process, and continuously registering their intensity, the metallurgical sequence of events may be followed.

Because the converter flame fluctuates strongly in intensity, direct measurements are not possible, and it is necessary to resort to comparing the intensities of two characteristic regions of the spectrum.

The instrument developed for this purpose (Fig. 3), consists of a single prism spectrometer with fixed prism and two slits, which also remain fixed. Behind the slits, two electron multipliers are situated, which give a current proportional to the intensity in the two regions of wavelengths. These photo-electric currents are amplified and their ratio is recorded on a compensating recorder. For industrial use, the spectrometer is built into a water-cooled housing, and its objective lens which is at a distance of approximately 3m from the mouth of the converter, is protected by a curtain of compressed air. The recorder is situated on the control stand next to the temperature-recorder. From the recording in Fig. 4, it is seen that the ratio of the characteristic radiations is low at first, and rises only slightly during the period of decarbonisation.

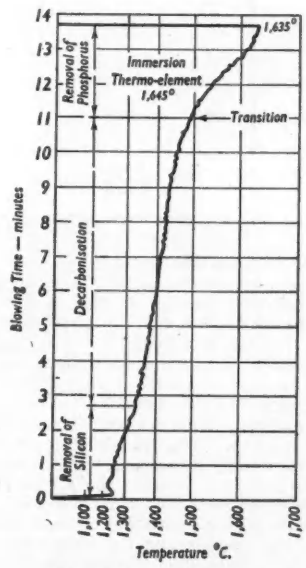

Fig. 2—Temperature curve

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† Dortmund-Hörder-Hüttenunion, Dortmund.

tion although the flame intensity increases considerably during this period.

During the transition the ratio changes very quickly, with a tenfold increase in a period of ten to fifty seconds. This change is due to a decrease in the violet component, the red components still showing a slow increase during this period.

During the first part of the removal of phosphorus which now follows, the spectrometer curve usually continues to rise slowly, although in some cases, it may remain level for a short time. One to two minutes before completion of the blow there occurs again a large increase. The curve reaches a maximum thirty to seventy seconds before the end and then drops again. Time and height of this maximum are characteristic for the progress of the blow and the end point of the removal of phosphorus.

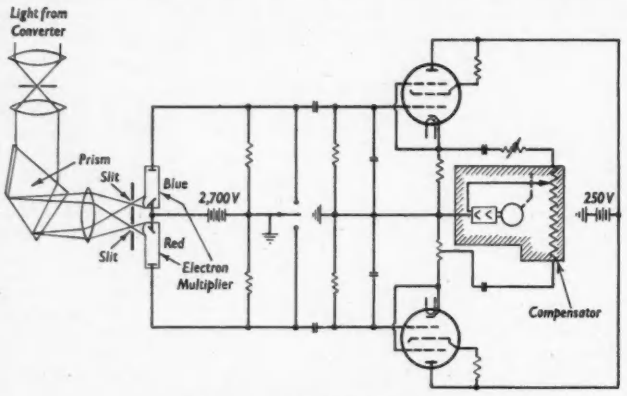

Fig. 3—Recording spectrometer

The rise in the spectrometer curve in the transitional stage is connected directly with the burning of carbon. Carbon monoxide possesses an extensive continuous radiation between 3000 Å and 5800 Å, which is probably a function of the burning of carbon monoxide to carbon dioxide. With the disappearance of the carbon monoxide at the end of the decarbonisation, this continuum also disapppears, so that the recorded intensity ratio increases very quickly. The rise in the curve during transition thus marks the end point of decarbonisation, the turning point of the curve coinciding with the transition point.

After the transition, the curve depends mainly upon the converter smoke which consists of small spheres of remarkably uniform size (Fig. 5). which increases towards the end of the blow It has been shown by means of X-rays that these spheres consist principally of FeO together with some Fe. In addition the smoke contains a certain amount of alkalis. The particles are smaller than the wavelength of visible light. On the one hand, they emit a continuous spectrum, on the other they disperse the light, dispersion of the violet being stronger than that of the red. It is this which determines the further shape of the spectrometer curve and its maximum.

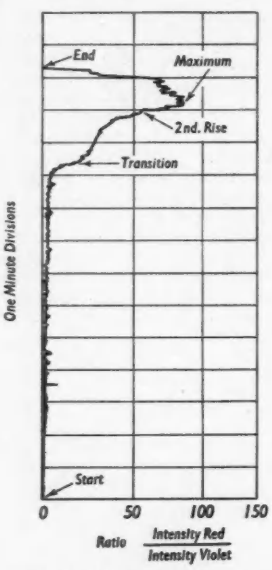

Fig. 4—Spectrometer curve

Fig. 6 shows the connection between the progress of the reaction and the temperature and spectrometer indications, in the case of two charges "A" (P=0·069 per cent) and "B" (P=0·074 per cent). The diagram shows as abscissa the temperature and as ordinates the amount of blast in cubic metres per ton which is consumed after the spectrometer maximum has been reached. A combined evaluation of the temperature and spectrometer curve, together with a knowledge of such quantities as the rate of blow, analysis of the pig iron used and its quantity, allows a continuous control of the process, and permits a check being kept on the removal of phosphorus during the last minutes of the blow. In this way the converter can be tilted in time and overblowing can be avoided.

Since April 1955, three converters of Dortmund-Hörder-Hüttenunion have been equipped with one set of instruments each. It became possible very soon to obtain better melts of more constant quality, so that the Thomas programme could be enlarged to include grades for which the maintenance of narrow temperature limits and avoidance of all overblowing is essential.

Statistical evaluation of the results revealed certain additional factors which cause the phosphorus content of the melts to differ from the values given by the diagram. There is, however, no inherent difficulty from the point of view of instrumentation to deal with all the factors which have been discovered. In this way, the accuracy of the method can be improved still further.

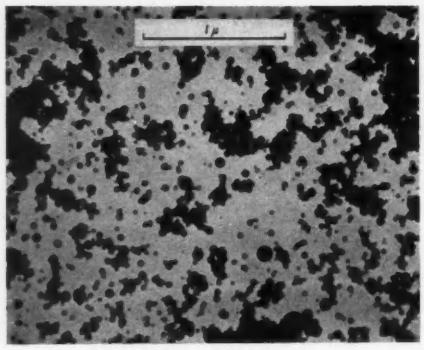

Fig. 5—Smoke particles formed during removal of phosphorous. The particles are mostly FeO and Fe

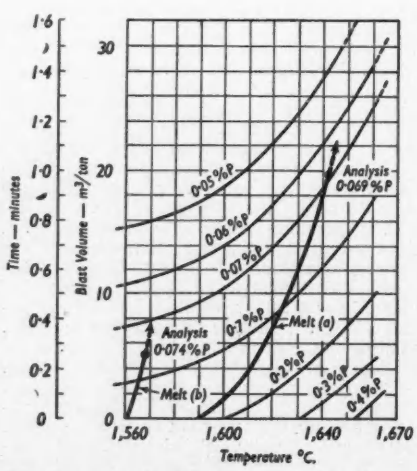

Fig. 6—Tracing of the phosphorous content of the melt

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[2] Frerich, R.: Stahl u. Eisen, 48 (1928), 1233-43. Gille, G., and J. Willems: Stahl u. Eisen, 69 (1949), 759-62. Naeser, G., and W. Pepperhoff: Stahl u. Eisen, 69 (1949), 391-98.

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[4] Wever, F., W. Koch, H. Höfermann, H. Knüppel, K. E. Meyer, and G. Weithoff: Archiv für Eisenhüttenwesen (forthcoming).

Mileage Recorder for Railway Vehicles

A MILEAGE recorder for mounting on railway vehicle axleboxes is now being made in two forms by the British Thomson-Houston Company, Ltd., Rugby. One form of recorder is a counter unit complete with drive and resilient mounting for attachment to an axlebox cover, as shown in the illustration below. This recorder is similar and interchangeable with the firm's "JB" tachogenerator for axle shaft drive. The other recorder is a counter unit with reduction gearing, for incorporation with the firm's "RC" tachogenerator, and driven from the generator shaft.

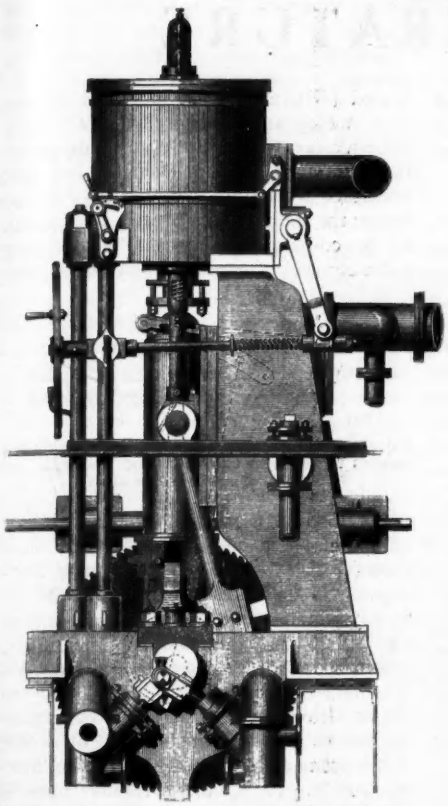
Mileage recorder for mounting on railway vehicle axleboxes

The recorder is essentially a six-figure counter assembly, the first wheel of which registers tenths of a mile and is actuated by appropriate reduction gearing from the wheel axle. The driving member can be varied to suit particular requirements and provision can be made to adapt recorders for track wheel diameters from 26½in to 55in.

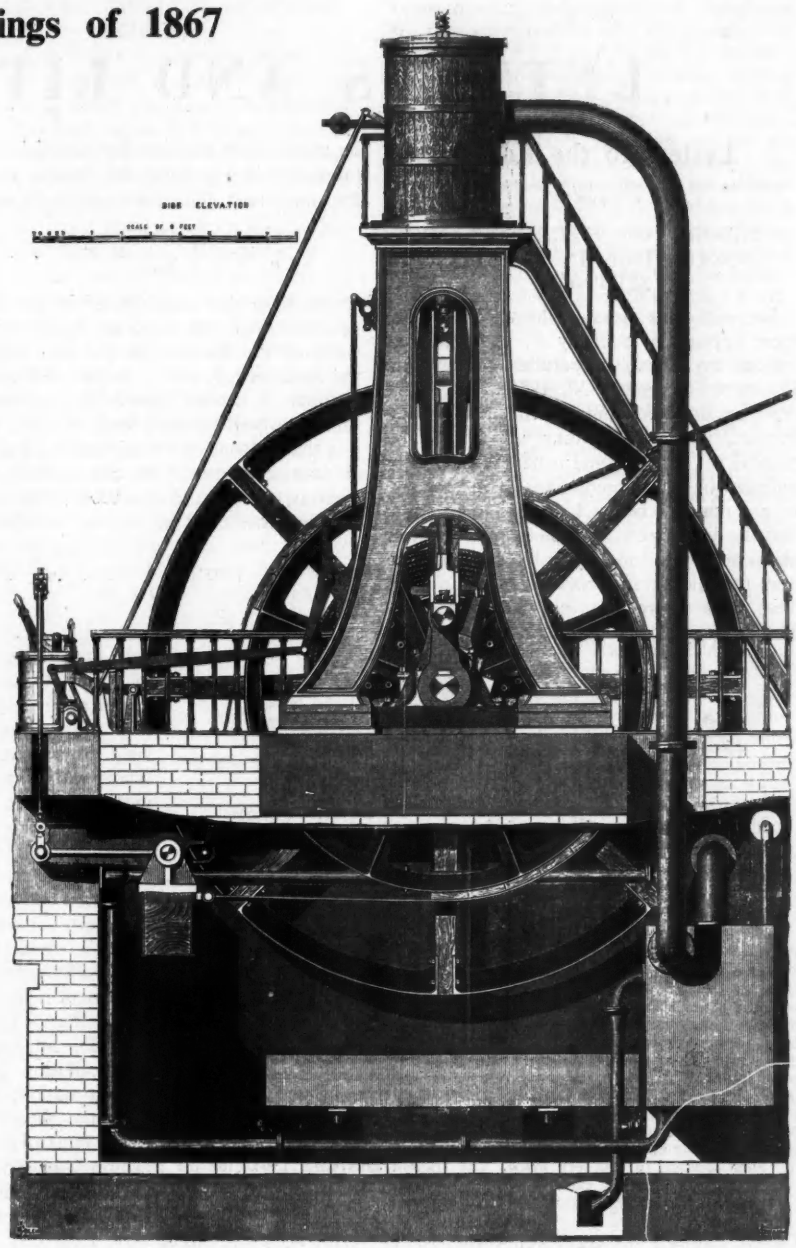
The mileage recorded is a function of the actual track wheel diameter and the gearing of the recorder. This gearing is chosen to match as closely as possible the mean diameter of the track wheel, taking into account the maximum tyre wear permitted; thus small errors due to variation in wheel diameter over the life of the tyre tend to cancel out over this period. A correction factor, which relates to the nominal wheel diameter as determined by the gearing, may be applied if more precise mileage figures are required over a brief period. For normal record purposes, however, the mileage figures shown are claimed to be of sufficient accuracy as the maximum error at any time will not exceed about 4 per cent.

MECHANICAL SEALS FOR PUMPS.—A new film entitled "Pumps Without Tears," which was made for Flexibox, Ltd., Nash Road, Trafford Park, Manchester, describes the firm's mechanical seals to pumping plant in oil refineries and chemical plants.

Engravings of 1867

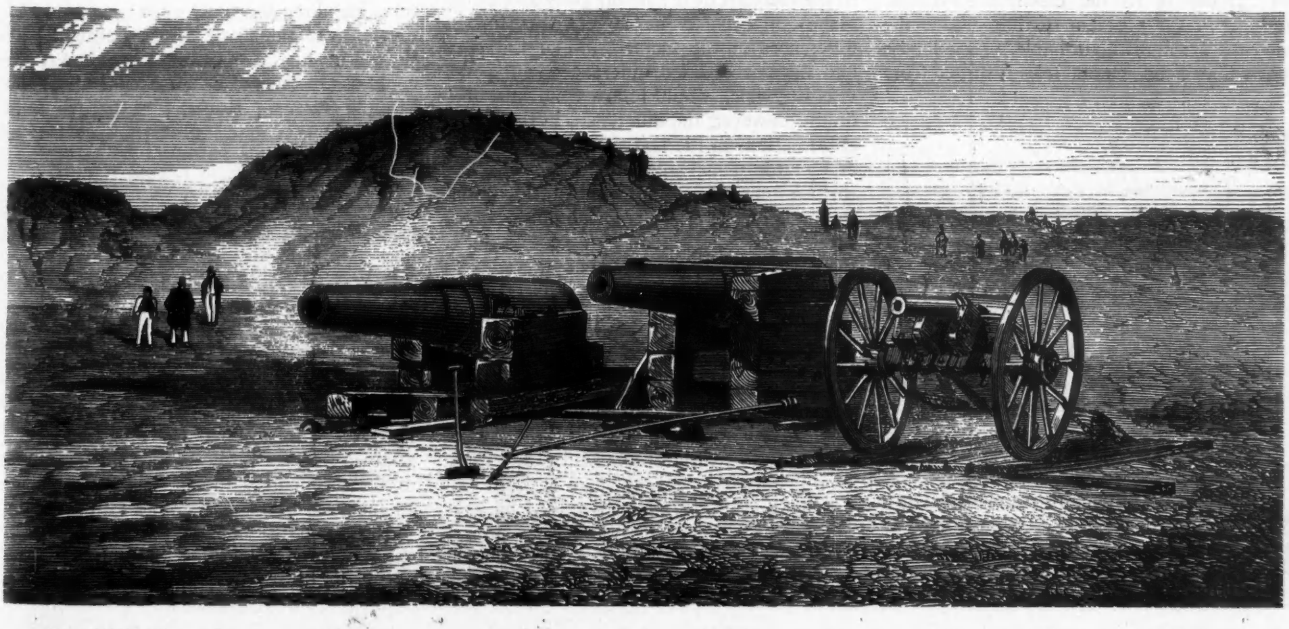


The engraving above shows an end view of a 70 h.p. marine engine which was built by Courtney, Stephens and Co., of Dublin, and first illustrated in our issue of November 8, 1867. Its cylinder diameter was 34in, and the stroke 26in



The 200 h.p. mine winding engine, illustrated by the engraving on the right, was shown at the Paris Exhibition in 1867. It was built by Dorzee, of Busseau, Belgium. The principal dimensions, given in a description in our issue of September 20, 1867, were : cylinder diameter, 3ft ; stroke, 4ft 7in ; interior diameter of winding drum, 5ft 11in

Below, there is reproduced, from our issue of October 18, 1867, an engraving of "Mr. Mackay's Battery and Targets on Crosby Sands." The small gun was a 12-pounder, the centre one a 6in, and the third gun, an 8in. Our comment was : "With much that is eminently satisfactory in the firing of the Mackay guns, there is much that is annoying and disappointing !"



LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

"THEORY OF HYDRODYNAMIC LUBRICATION IN PARALLEL SLIDING"

SIR,—In your issue of March 16, 1956, there appears a letter by V. H. Brix concerning my theory of parallel sliding (THE ENGINEER, December 30, 1955). Mr. Brix describes an interesting experiment in sliding friction, where the sliding appears to be parallel yet the frictional behaviour is widely different from the predictions of my theory. In my remarks below I am trying to show that the difference is not due to any weakness of my theory but merely to the circumstance that the sliding in Brix's experiment must have been convergent, not at all parallel. The experiment is a typical case of centrally loaded sliding; its confusion with parallel sliding no doubt arose from the circumstance that according to the classical Reynolds' solution of the problem of fluid wedge the two cases are undistinguishable. The analysis shows that if the external load is shifted from its steady-state position for parallel sliding (at $\varepsilon=b/3$ in Fig. 1) to the middle ($\varepsilon=b/2$), the minimum film thickness increases to

$$\frac{h_0}{b}=0\cdot925\left(\frac{\eta U}{N}\right)^{\frac{1}{2}}=0\cdot806\mu^2 \quad . \quad . \quad (1)$$

where η is the viscosity, U is the sliding velocity, N is the external load per unit width of the fluid wedge, b is the length of the fluid wedge, and μ is the coefficient of friction. I usually reserve the notation W for the overall external load, $W=aN$, where a is the width of the fluid wedge. Equation (1) is concerned with the case of wide slider, such as, for instance $a=100b$. The corresponding coefficient of friction is reduced to

$$\mu=1\cdot071\left(\frac{\eta U}{N}\right)^{\frac{1}{2}} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

This friction is plotted in Fig. 2, together with Brix's experimental results taken from Fig. 4 of his letter. It is probably not quite right to compare the theory with experiment in this manner, since no doubt each refers to a somewhat different geometrical configuration of the sliding pad. It seems to be clear, nevertheless, that a wide measure of agreement is achieved. Note that equations (1), (2), are not an exact solution but an approximation. However, the theory does not include any arbitrary or empirical parameters and it seems that its inherent error does not exceed, say, 1 per cent. The scatter of the experimental results (according to the material of the sliding pads and of the plane) appears to be largely due to the differences in the temperature of the pads and the unaccounted differences in the film viscosity which would follow from this. No doubt, however, the differences in the elastic deformations in the body of the sliding pads and in the plane are partly responsible for this scatter. It would perhaps be relevant to mention in this connection that the necessary degree of convergence to achieve the sliding in accordance with (1) and (2) is supposed to arise spontaneously and as a matter of dynamical equilibrium, without any resistance offered by the deflection of the pads at an angle.

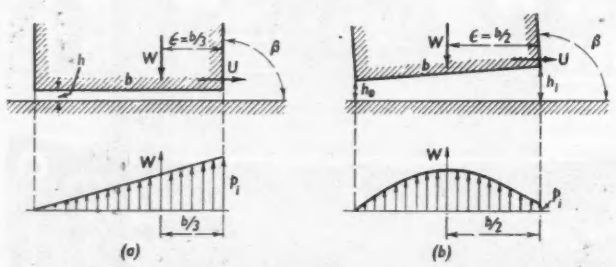


Fig. 1—The mechanism of building up the inlet pressure p_i in the lubricated sliding. The case (a) is the parallel sliding and (b) is the centrally loaded mode. In both cases the inlet pressure arises from the leading face acting as a convergent slider joined in series with the underface. The fluid wedge which is being sheared at the inlet has a wide leading angle (β). Its pressurising action is usually quite small, but it becomes prominent when the underface of the pad is parallel on account of a sharply decreased film thickness and the parallel face having no pressurising power at all. In the case (a) the load W must be applied at the distance b/3 from the leading end. The case (b) arises automatically when the load is shifted by b/6, from b/3 to b/2. The unevenly distributed pressure under the pad causes its body to tilt backwards. This gives the underface a pressurising power, which is very strong on account of the tilt being small. This jacks the pad up and causes the inlet pressure to fall very much. The friction falls from 1·047 for the parallel case to between 0·03 and 0·01

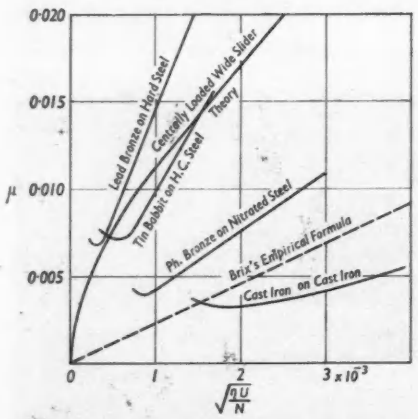


Fig. 2—The theoretical friction [equation (2)] for the centrally loaded wide slider is plotted against the values observed by Brix (Fig. 4 of his letter)

Surprisingly enough, it looks that this assumption is permissible in conjunction with rigidly held "parallel" sliding pads, just as well as with loosely held piston rings. In order to show that this can easily be the case with the experiment described by Brix, consider a numerical example: Fig. 3 represents a somewhat simplified version of his experiment. The two pads are evenly loaded (W), move with the same velocity (U); they are short in height ($c=0\cdot2b$) but wide ($a=100b$). Both are rigidly joined to a substantial cross-member (A) and their underface is carefully adjusted (by lapping) before the sliding under load is commenced, to be co-planar. Suppose that the twin slider is made of hard steel and that it slides under load in a pool of lubricant over a substantial hard-steel plane, that the mean external load $W/ab=1$ kg per square centimetre. If the sliding remains parallel we have just about zero pressure at the trailing end of the underface and 2 kg per square centimetre at the leading end. The reduction in length of the leading face ($0\cdot2b$) by an elastic deformation under 2 kg per square centimetre is very small ($2\cdot10^{-7}b$). But, if it is assumed that the minimum film thickness is $h_0=10^{-4}b$, there results quite a tangible film ratio $\alpha=1\cdot002$. I call it tangible because the before-mentioned analysis shows that the equilibrium value of the film ratio is only about $1\cdot02$. However, the computed elastic deformation is evidently but a minute fraction of the overall deformation, including the body of the support and the body of the plane, as diagrammatically shown in Fig. 4. Clearly, the film ratio could easily become $1\cdot2$ or even 2 under the bending moment caused by the unevenly distributed pressure along the fluid wedge. However, the required $\alpha=1\cdot02$ would be attained with the help of only a small fraction of the originally assumed bending moment. In fact, the pressure becomes automatically redistributed, to be much more even than the somewhat precarious linear distribution. There is a drastic fall in the inlet pressure on

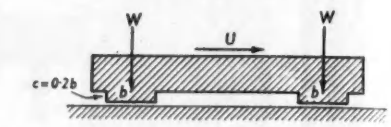


Fig. 3—Twin centrally loaded slider. The sliding appears to be parallel but is in fact convergent, on account of elastic deformations

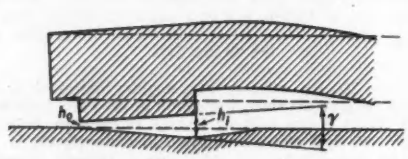


Fig. 4—The elastic deformations in the body of the twin centrally loaded slider and in the supporting plane, on a vastly magnified scale. The angle γ is in fact only of the order of 0·001 to 0·0001 of a degree

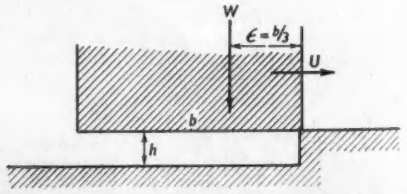


Fig. 5—Physical meaning of the assumption q=0 in the empirical formula given by Brix [equation (3)]

account of the increased film thickness. In comparison with the strictly parallel sliding the minimum film thickness increases something like 100 times and there is a similar reduction in friction. Note that in equilibrium at $h_0=10^{-4}b$ the angle of overall convergence is only about 0·0001 of a degree. At first sight it is perhaps difficult to understand how can it be that such a minute convergence can be responsible for the hundred-fold change in the film thickness and friction. There is no doubt, however, that in reality the effect does occur much as described by this theory. It will be remembered that the effect is really due to the substantial shift of the external load by $b/6$ in Fig. 1, from $\varepsilon=0\cdot333b$ to $0\cdot5b$.

Turning now to other problems raised in the letter, I note with interest that the author makes use of the notion of vorticity in discussing the problems of sliding friction. The principle itself is, of course, well known, but its implications have perhaps never been worked out sufficiently in conjunction with the theory of sliding friction. Another point of interest, the term "boundary friction" or "boundary film" does not appear in the letter. Quite rightly, because, as I have pointed out elsewhere, the common kind of friction in engineering is bound to be hydrodynamic throughout. In this connection, I do not think the author is fully justified in suggesting that the lubricant film begins to form hydrodynamically when an appreciable electric resistance appears in passing a current across the film. The point is that an electric breakdown of a fluid layer is not a mechanical breakdown. All sorts of things may precipitate an electric breakdown and cause a virtual disappearance of the resistance across a substantial layer of liquid. For instance, the lubricant usually carries countless minute dust-like particles of metallic debris. They may be too small to be removed by filtration yet large enough to bridge the gap momentarily and to set on a lasting electric discharge, or many of these on their path. A word now about the formulæ proposed by Brix.

$$\frac{h}{b}=1\cdot732\left(\frac{\eta U}{N}\right)^{\frac{1}{2}}\ ;\quad \mu=2\cdot309\left(\frac{\eta U}{N}\right)^{\frac{1}{2}}=1\cdot333\left(\frac{h}{b}\right) \qquad \ldots\ldots (3)$$

In deriving them the author puts $q=0$. By doing this he in effect puts an imaginary material barrier across the film, not unlike shown in Fig. 5. These formulæ have a definite physical meaning only when such an obstacle is really there. Note that by (3) the film thickness is proportional to the coefficient of friction while in my centrally loaded sliding theory the film thickness is proportional to the square of the coefficient of friction. Of course, the relations are bound to be different in the case of round sliding pads, but they still remain to be found. Finally, I would like to mention that Brix's earlier writings* seem to contain a good many useful observations on the problem of surface wear, &c., some of which could perhaps be taken up in order to widen the scope of the present discussion.

W. LEWICKI

Department of Chemical Engineering,
Imperial College of Science and
Technology, London.

* V. H. Brix, *Aircraft Engineering*, December, 1944, July, 1947, September, 1947.

AUTOMATIC CONTROL OF STEAM BOILERS

SIR,—A well-known boiler insurance company has published a pamphlet entitled "Mishaps to Steam Boilers under Automatic Control," which is, in fact, a plea that all steam boilers should be attended and that they are not suitable plant to be left under automatic control.

It is clear from the examples given that the failures are due to the misapplication or misuse of the control devices and that the failures on which the insurance company's plea for attendance is based are primarily due to a misunderstanding of the requirements of automatic control. The main justification of automatic control on smaller plant is that, correctly applied and properly maintained, it can replace attendance.

The booklet referred to assumes that a boiler attendant would be sufficiently conscientious to ensure safety. Why should not the management or those who have to maintain the controls accept a similar responsibility ? In a less highly developed society it may not be possible to put the responsibility on someone not present when a failure occurs, but it is ridiculous to suggest that this is true in this country. It is only by making use of our technical ability in such ways to save manpower that we can maintain our standard of living above that of most of the world.

HENRY CLAY

Westminster,
May 4th.

Literature

Color Television Engineering. By JOHN W. WENTWORTH. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 60s.

THIS is a book for the serious television engineer who wishes to understand the principles of colour television as developed in America. As the basic principles of colour perception have been so carefully considered in the development of the N.T.S.C. system, it is practically essential that the engineer should know about them, and the author is therefore wise to devote over a third of the book to the perception and measurement of colour, including colour photography. This is so well written and is done with such familiarity with the subject that we found it at least as interesting as the rest of the book. In this section of the book the operation of the eye is very fully described and the mechanism of colour vision is explained so far as it is understood at the present time. In particular the failings are discussed so that the cunning of the N.T.S.C. system, which exploits such "failings" can be understood and appreciated.

It is pleasing to read of the international agreement which has taken place in the methods and standards used in colour measurement. Following the chapters on basic principles there is a chapter on transferring colour and the effects of distortions in the transferring system. After reading this chapter it seems impossible that acceptable television, particularly colour television, is achievable at all !

A chapter on colour television as an information transfer system follows. Starting with a possible colour system using three complete chains, one for each of the three primary colours, the practical difficulties are discussed, the importance of frequency spectrum conservation and the problem of compatibility. It is also shown how suitable bandshaping and matrixing methods applied to the red, green and blue signals can produce signals which contain enough "information" to produce acceptable colour images, but yet occupy a reasonable frequency spectrum, the same as a monochrome signal. The introduction of the sub-carrier is next described and the principle of frequency interlacing or bandsharing. As this is such an important part of the system it is proper that the author should be so careful in his treatment. Time-multiplex or sequential colour systems are then described.

A chapter on colour transmission equipment is then included. Several of the special circuits used are described in some detail, gamma correction, for instance. The two end chapters are concerned with colour receivers and test equipment. These are not only interesting from a colour receiver point of view, but also as an indication of circuit development in the U.S.A. Most of the sections of a colour receiver are described and are illustrated by clear circuit diagrams, with component values. These chapters will undoubtedly be the most interesting for the majority of readers. The service man will find details of still more equipment that he will need, and it is interesting to see that commercial equipment is already available. The book concludes with an appendix containing much useful data.

It is difficult to criticise a book which is the result of so much effort and is so workmanlike, but a few points may be mentioned. No reference at all is made to any work outside the U.S.A. and this is unfortunate, particularly in the field of colour measurement. On page 186 there is reference to papers said to be listed at the end of the chapter, but which do not appear. A useful bibliography is included at the end of each chapter. Too much space is wasted on photographs of equipment. In most cases these serve no useful purpose. For instance, on page 333 there is a "photograph of a typical colorplexer." It could be almost any multi-valve electronic equipment and the form of construction is neither original nor significant. The most serious criticism is, however, the lack of colour. Only one page contains colour photographs and on the reverse side of this page appears three small colour wedges. The beginner in colour would find the chromaticity diagrams so much easier to understand if at least one was in colour; this applies to the wavelength diagram and Munsell colour circle.

Books Received

Frequency Response. By Rufus Oldenburger. The Macmillan Company, New York, 10, South Audley Street, London, W.1. Price 52s. 6d.

The Steam Boiler Yearbook and Manual (V). By R. J. Millson. Elek Books, Ltd., 14, Great James Street, London, W.C.1. Price 42s.

Higher National Certificate Workshop Technology. By T. Nuttall. The English Universities Press, Ltd., 102, Newgate Street, London, E.C.1. Price 30s.

Les Applications de L'Explosion Thermonucléaire. By Camille Rougeron. Editions Berger-Levrault, 5, rue Auguste-Comte, Paris (VI^e). Price 600 francs.

Electrical Who's Who. Fourth edition. Compiled by *Electrical Review*. Electrical Review Publications, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 21s.

Marine Auxiliary Machinery. Second edition. Edited by E. Molloy. George Newnes, Ltd., Tower House, Southampton Street, Strand, London, W.C.2. Price 35s.

Reactor Handbook—Engineering. U.S. Atomic Energy Commission. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 112s. 6d.

Exhibition of the Physical Society

No. I

THE fortieth Physical Society Exhibition will be opened on Monday next by Sir John Cockcroft. It occupies the Old and New Halls of the Royal Horticultural Society, and continues until Thursday, May 17th. Due to the participation of a greater number of universities, colleges and research organisations, the proportion of purely research exhibits is expected to be higher this year.

On Monday, at 6.15 p.m., Mr. H. G. Jenkins will lecture on "Recent Developments in Light Sources." At the same time on Tuesday, the subject taken by Professor H. Lipson will be "The Production of Images of Chemical Molecules"; a technique is presented whereby, instead of computing the form of a crystal from observations of X-ray diffraction, the X-rays are converted into light beams with corresponding dispositions, intensities, and phases. These light beams can be focused and an image of the atomic structure of the crystal produced. Mr. G. G. Gouriet, at the same time on Wednesday, discourses on "Colour Television: Considerations which have led to Recent Trends." It will be shown that the early proposals called for prohibitive amounts of ether space, while more recently it has become desirable that the transmission shall be successfully received by the prevalent monochrome receivers.

On Thursday at 3 p.m., the prizegiving of the Craftsmanship and Draughtsmanship Competition takes place; the entries will be on show.

A number of the exhibits are described in the following paragraphs.

Royal Aircraft Establishment

Aeroplanes and missiles have been found to suffer seriously from erosion when flying through rain at high speeds. In studying the fundamentals of this process, it is not found possible to accelerate drops of water to the required speeds without the drop shattering. The apparatus to be demonstrated shoots the surface at a stationary drop of water, which is suspended on a fine web made from "Perspex" dissolved in aniline. The surface under test forms the nose of a bullet which is fired from an airgun by a rapidly opening valve fed with high-pressure air. The air preceding the projectile blows the web away and the drop is left to be struck by the body; high-speed photographs illustrate this. The bullet is decelerated by a series of washers arranged at intervals in a tube: the impact surface passes undamaged through the holes in the washers and the conical taper of the body deforms the soft aluminium. At a speed of 800ft per second a 2·5mm raindrop leaves a depression resembling a Brinell impression on a solid aluminium projectile. On a "Perspex" surface an annular imprint surrounded by fine crazing can be seen under magnification. Mercury drops have also been used, and it is proposed to fit a piezo-electric crystal in the bullet to measure impact forces.

The Establishment will also demonstrate a high-speed sequential sampling switch, adopted to measure potentials of the order of 1mV. The rotor runs at 800 r.p.m. and acts as an impeller, drawing mercury from a pool and ejecting it from an orifice 0·010in diameter. This fine jet impinges on a ring of sixty insulated points, connecting each in turn with the pool. This switch could be used to sample an assembly of strain gauges or in similar applications: a pair running in synchronism will be shown, arranged so that the first passes the outputs of a series of analogue computers to a drift correcting amplifier, while the second feeds the amplifier outputs, through filters to the appropriate computer.

Armament Research and Development Establishment

An extensometer developed to allow gauge lengths of less than ½in to be utilised will be among the devices demonstrated on this stand. Two legs, joined by a steel strip hinge, end in knife edges which define the gauge length. At their opposite ends the legs carry plane mirrors inclined at 45 deg. to the leg, and at right angles to each other. These mirrors form a constant deviation prism, and if observed through an auto-collimator give a single image when inclined at 90 deg. exactly; an extension of the gauge length moves the mirrors and two images appear. Movement of the auto-collimator does not alter the distance between the images, which varies directly as the extension.

Measurement of the extension may be carried out in two ways:

(i) A standard eyepiece micrometer may be used to read the movement of one image from the axis of the instrument. In this particular instrument one-half of the graticule has to be obscured so that only one image is visible, and we have a working scale of forty minutes, subdivided to 0·01 minute by the micrometer drum.

(ii) An external optical micrometer is used to compensate for the angular movement of the mirrors and to keep the two images in coincidence. This micrometer consists of two circular glass wedges, which are mounted axially on a common shaft and can be counter-rotated, the amount of rotation being read on a vernier scale. The wedges are placed below the axis of the auto-collimator so that only half the light from the object glass passes through them. This gives an arrangement by which light returning from the mirrors of the extensometer may be deviated back so as to make the images coincide. The amount of rotation of the wedges to restore coincidence of the images is a measure of the movement of the mirrors and of the extension of the test piece.

The micrometer eyepiece first described is the more accurate, but the scale is limited to forty minutes by the optical characteristics of the eyepiece; but for proof stress determination it is satisfactory as, with the 0·325in gauge length extensometer exhibited, it is capable of measuring a 1 per cent extension of the gauge length with an accuracy of 1×10^{-6}in. The external optical micrometer has a lower accuracy of reading, but the scale has a range of eighty minutes which suits it for larger extensions.

The instrument is easily made and has proved itself robust. Since movement of the auto-collimator is insignificant, for purposes such as creep testing several extensometers could be metered by one auto-collimator.

Barr and Stroud, Ltd.

The Chart Comparison Unit seen in Fig. 2 allows a navigator to observe a radar plan-position-indicator display superimposed upon his chart. Thus objects seen on the radar 'scope can be positively identified, and if a stabilised p.p.i. presentation is used, one landmark can establish the observer's position directly. Provision is also made for the ship's position and heading to be projected on to the chart.

The C.Y.5 unit fits on to a 5in radar screen and the display is viewed directly by a beam-splitter and an eyepiece. The chart is laid on a table below the instrument and illuminated by a shaded light: an image of it is formed by an optical system and reflected into the eyepiece by a beam-splitting device. This latter is based on the interference principle, thin films of metal or di-electric substance being deposited on the glass under high vacuum, and the prism gives separated beams which are neutral for colour. A variable-density filter, controlled by the knob below the instrument, balances illumination between chart and 'scope images. Partly hidden on the far side of the instrument is the change scale operating head, which varies the magnification of the chart continuously to allow its image to be matched to the p.p.i. picture. When a stabilised radar plot is used a graticule appears in the eyepiece to assist in lining up the chart. It is the task of the navigator to move the chart under the instrument as the ship proceeds. A projector points on the chart an illuminated circle containing an arrow: the course scale on the projector allows this arrow to be set to show the ship's heading, while the projector is set so that the circle is centred on the present position. An iris aperture setting varies the brightness of this circle to contrast well with the chart. Similar instruments are used by H.M. ships for navigational and surveying duties.

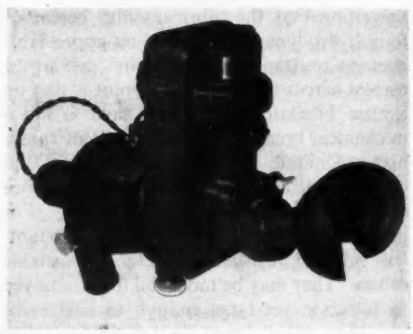


Fig. 2—This chart comparison unit allows the plan position indicator to be seen superimposed on a chart. The projector, at left, shows the ship's position on the chart—Barr and Stroud

H. W. Sullivan, Ltd.

One of the principal exhibits on this stand will be the Sullivan and Griffiths decade air condenser. This is essentially a substandard of capacitance, and is intended to simplify the problem of the scale reading of a continuously variable air condenser, without loss of ultimate accuracy.

The design is fundamentally that of a variable air condenser having the conventional interleaving systems of semi-circular fixed and moving plates, but the latter are fingered radially into a decade of sectors, as will be seen in the illustration of the exhibit. The fingers are rotated into

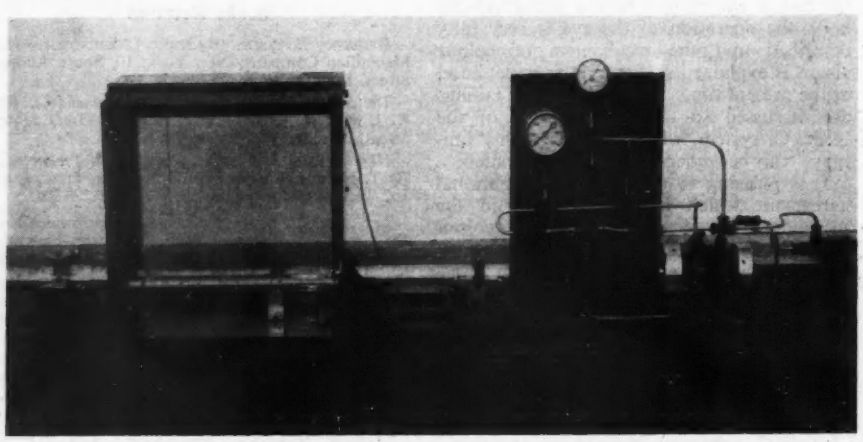


Fig. 1—Apparatus for examining erosion by raindrops; the drop hangs in the circular frame seen through the bottom left corner of the window—Royal Aircraft Establishment

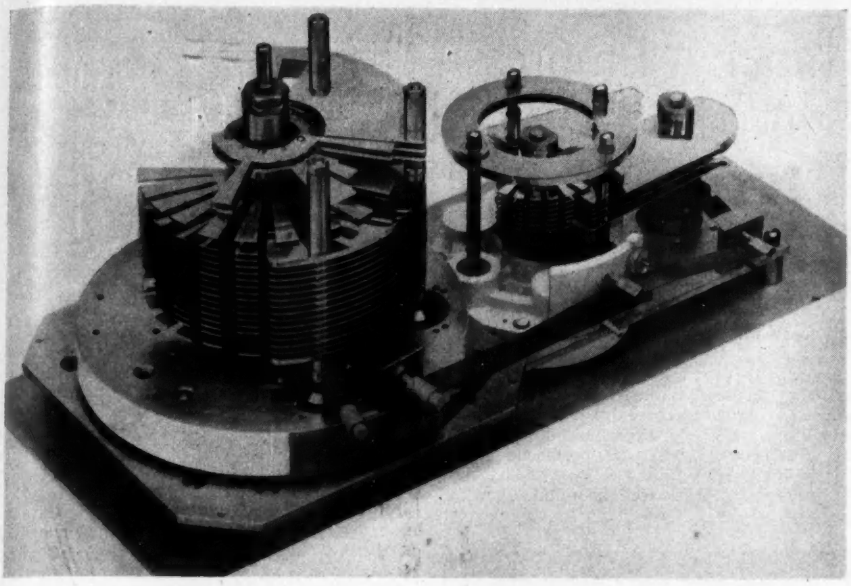


Fig. 3—Decade air condenser. It is continuously variable and reads directly in pica-farads—H. W. Sullivan

the fixed plates to give the required capacitance increments, the relative position of the fixed and moving plate systems for each increment being determined by a "click" device. This click ensures that the radial edges of the fixed plates (into which the moving plates are entering) always approximately bisect the angular gap between adjacent fingers. Thus small angular movements from a "clicked" setting produce no corresponding change in the active (interleaved) area between the two plate systems, the chief capacitance change being that caused by the change of edge capacitance between the radial edges of the fixed plates and the leading edges of moving plate fingers next to enter the fixed plates.

Thus a very stable capacitance is provided at every decade position—almost the equivalent of ten fixed value air condensers—and with the added advantage that the troublesome switching means is avoided in the present design. The dependence of capacitance stability upon angular certainty is in this decade design less than one-hundredth of that of a variable condenser of conventional design and of comparable range.

The model shown in Fig. 3 has a premier decade of 1000 $\mu\mu F$ in increments of 100 $\mu\mu F$, a second decade of 100 $\mu\mu F$ in increments of 10 $\mu\mu F$ and an ultimate continuously variable unit in which the direct reading scale has been simplified one hundred times by the introduction of the prior decades. Thus accuracies of 0·01 per cent are possible without elaborate scale dividing.

SIEMENS BROTHERS RESEARCH LABORATORY

Prominent on this stand will be an experimental electronic telephone exchange, inspired by the similarities between digital computers and telephone systems and by the desire to eliminate the wear associated with electro-mechanical equipment: on account of the high operating speeds of electronic devices, an exchange incorporating them can be made to set up calls one at a time even when handling heavy traffic. The equipment displayed, which has no moving parts, was built in the course of long-term research into these possibilities.

The model uses a time-division multiplex (t.d.m.) system of switching in which independent connections between telephone subscribers are established by connecting them together in pairs at different times over a common path, at a repetition frequency sufficiently high to retain the standard quality of transmission required in a telephone system. Although the model has only four lines equipped, the t.d.m. system can provide up to ninety-nine channels. The pulse repetition frequency for each channel is 10 kc/s and each pulse is 0·25 microsecond wide. Subscribers' lines are connected to one side of the switch and interconnecting trunks to the other. Thermionic valves, cold-cathode valves and semi-conductor devices are used in circuits which perform the many functions necessary to control the switching of calls through this automatic exchange.

The general appearance of the model exchange is illustrated in Fig. 4. The left-hand rack contains the circuits for generating all the pulse trains required, together with supervisory tones and ringing current. The adjacent rack contains the switching equipment. In the centre of this rack is the t.d.m. apparatus in a "honeycomb" form of mounting. Above this on the left are two supervisory units for the connecting trunks and on the right are the subscribers' line circuits with their meters. Below the t.d.m. apparatus on the left are the subscribers' line distribution panel and the register-marker which is required to receive and store the digits dialled by subscribers because these are sent at the slow speed of 10 impulses per second, whereas the electronic switch sets up the required connecton in a few milliseconds. On the right are mounted the magnetostrictive delay lines which are used for holding the required connections throughout each call. Above the model is mounted a functional diagram on which coloured lights display the action of the exchange while calls are being set up. The sequence of events is too rapid to follow in detail, but can be slowed for demonstration purposes by operating keys.

When a subscriber lifts his handset, he is connected to the register-marker which transmits dial tone to him. When he dials, the register-marker receives and stores the called subscriber's number and marks that subscriber's circuit in the multiplex switch. If the number is unobtainable, N.U. tone is sent back. If it is obtainable, the marking condition is extended over the trunks if they are free. If both trunks are marked one is selected and the register is connected to the called line over the selected trunk. If the called line is busy or both trunks are busy, the register returns busy tone to the calling subscriber. When the register has set up the call it releases itself, leaving the calling and called lines connected together by the trunk. The supervisory unit in the trunk causes ringing tone to be sent to the calling subscriber and ringing current to the called subscriber until the latter answers. When the called subscriber answers, the ringing and ringing tone are tripped and the calling subscriber's meter is operated to charge for the call. The trunk is released when the calling subscriber replaces his handset.

BRITISH THOMSON-HOUSTON COMPANY, LTD.

On this stand there will be demonstrated a method of determining local temperatures and pressures in the oil film of a journal bearing. The sensitive elements are located in the shaft, thus obtaining a complete circumferential distribution as the shaft rotates: by using several elements mounted in different axial positions, or by moving the shaft through the bearing, the distributions over the whole oil film may be obtained.

The pressure sensitive element consists of a small piezoelectric crystal (3mm by 3mm by 1mm) cast in resin so as to lie just below the shaft surface, the resin forming the surface at this point. The oil pressure is transmitted to the crystal by the thin layer of resin and the signal from the crystal is fed by mercury sliprings to an amplifier. The temperature sensitive element is 0·001in diameter tungsten wire of semicircular cross-section mounted in the shaft in resin in such a way that the flat forms part of the shaft surface. This wire is used as a resistance thermometer, the signal again being fed to the measuring apparatus by mercury sliprings. The small thermal capacity of the wire ensures a rapid response to changes in temperature, and as the shaft rotates a complete circumferential temperature distribution is obtained. The response time of the wire is reduced by electronic means for the higher ranges of shaft rotational speed.

(*To be continued*)

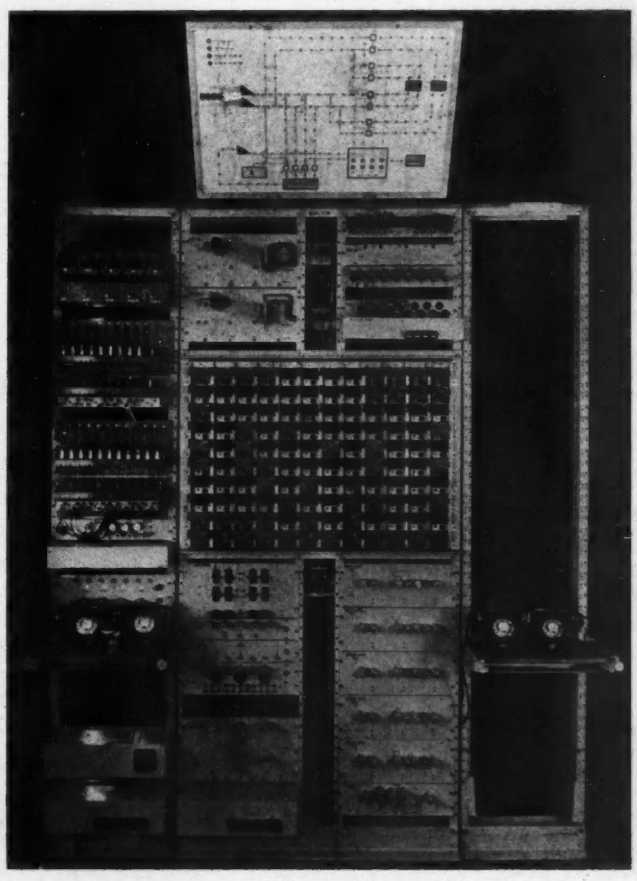


Fig. 4—An experimental electronic automatic telephone exchange to provide 99 channels—Siemens

Canadian Pacific Liner "Empress of Britain"

No. I

The "Empress of Britain" recently entered the North Atlantic service of Canadian Pacific Steamships, Ltd., and has accommodation for 150 first and 900 tourist-class passengers. Of 26,000 gross tons, the ship has an overall length of 640ft, a beam of 85ft, a depth moulded of 48ft, and is designed for an average service speed of 20 knots. Two sets of double reduction geared turbines, developing 27,000 s.h.p. in service, propel the liner and are supplied with steam at 600 lb per square inch gauge and 850 deg. Fah.

Main Particulars and Dimensions

Length overall	640ft
Breadth moulded	85ft
Depth moulded to "B" deck	48ft
Load draught	29ft
Service speed	20 knots
Gross tonnage	26,000 tons

Accommodation

First-class	150
Tourist-class	900
Crew	464

Propelling Machinery

Twin-screw double-reduction geared turbines

Normal service output	27,000 s.h.p.
Maximum output	30,000 s.h.p.
Steam supply	600 lb per square inch gauge, 850 deg. Fah.

Two Foster Wheeler water-tube boilers and one Foster Wheeler reheat boiler :

Steam pressure	650 lb per square inch gauge
Superheat	850 deg. Fah.

One Howden-Johnson auxiliary boiler :

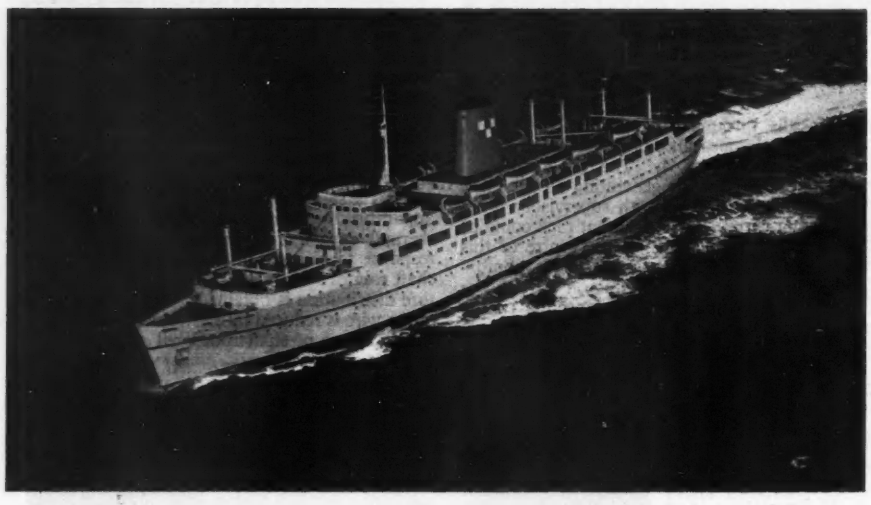
Steam pressure	200 lb per square inch gauge

Electrical Machinery

Two turbine-driven Allen generators	1200kW
Three diesel-driven Allen generators	500kW
Two emergency generators	100kW

Driven by National diesel engines.

THE third ship to bear the name "Empress of Britain" entered the service of Canadian Pacific Steamships, Ltd., when this latest addition to the fleet sailed from Liverpool on April 20th on her maiden voyage to Canada. The liner has been built and engined by the Fairfield Shipbuilding and Engineering Company, Ltd., the company which constructed the first ship of the name in 1906, and which has been responsible during the intervening years for building twenty-one ships for the Canadian Pacific Railway Company, including the "Empress of Russia," the "Empress of Asia," and the "Empress of Japan." Building commenced with the laying of the keel on September 30, 1953, and, as recorded in our issue of July 1, 1955, the ship was named and launched on June 22nd last year by Her Majesty the Queen. This is the first passenger liner ordered by the owning company since the war and the new ship replaces the second "Empress of Britain," which was completed in 1931 and which became a war casualty in 1942.



The Canadian Pacific liner "Empress of Britain" on trial

Our illustration shows that the ship has been given a well-balanced and pleasing profile with the superstructure decks being echeloned forward and aft to avoid any suggestion of topheaviness. The hull form, which has been tank tested in both smooth and rough water, is of normal design and embodies a raked contour plate stem and cruiser stern. There is a single mast and a large single buff funnel, with the red and white chequered house flag painted on each side, and above the green boot-topping the whole of the ship is painted white, except for a green riband at about the level of "C" deck. The shape of the funnel was determined after smoke elimination tests at the National Physical Laboratory. It is constructed of aluminium alloy and has soot extractors fitted in the uptakes and is expected to be effective at a speed of 20 knots with a 20-knot wind and an output velocity of 80ft per second.

Construction of the ship conforms with all the requirements of the Ministry of Transport and with the rules of Lloyd's Register of Shipping, and the degree of subdivision, based on a two-compartment standard, is such that the metacentric height in the damaged condition is adequate to satisfy the onerous conditions laid down. There are seven decks, namely boat, promenade "A," "B," "C," "D," and "E," of which "B," "C," and "D" are continuous, while "A" extends for practically the whole length. All the decks with the exception of "E" are occupied either wholly or in part by accommodation for the passengers and crew and ancillary services. Longitudinal and transverse framing have been adopted for the hull, which is extensively welded, the shell embodying a certain amount of special welding quality steel, namely, at the keel, for the sheerstrake and for two strakes of plating near the waterline. Special attention has been paid to the weather conditions obtaining in the North Atlantic, and the scantlings of both the framing and the shell forward have been increased for navigation in ice. Riveting has been adopted for the framing and for four shell seams on each side, while all butts are welded. Within the main hull the deck plating and beams are welded, but elsewhere riveting has been mainly used. Subdivision is effected by eleven watertight bulkheads carried up to "C" deck, the bulkhead deck, and above this level the ship is divided into seven zones by six fireproof divisions.

Particular attention has been paid to the effectiveness of the steering arrangements, since good manœuvrability is essential when navigating the St. Lawrence. To this end steering trials were carried out at the model stage and tank tests indicated that the rudder would give positive control at 5½ knots. Passenger comfort is also ensured by the fitting of a pair of Denny-Brown stabilising fins and operating gear.

Water ballast is arranged to be carried in the peak tanks and also as an alternative to fresh water in the double bottom under the three forward holds and aft in way of the shaft tunnels. Fresh water is carried in the double bottom under the boiler-room, in wing tanks in the engine-room and at the sides and in between the shaft tunnels in way of No. 5 hold. For the carriage of oil fuel there are athwartship tanks aft of No. 3 hold, tanks to port and starboard of the auxiliary machinery space, and in the corre-

Part of first-class club room giving view of drawing room

First-class restaurant

sponding double bottom spaces. Three cargo holds and associated 'tween decks are located forward of the bridge and a similar number, one of which, No. 5, is insulated, are arranged aft of the engine-room. Flush hatch covers are fitted in way of passenger open deck spaces, and the capacity of the cargo holds is 380,650 cubic feet, while that of the refrigerated spaces is 80,000 cubic feet.

Accommodation

The liner is completely air conditioned, the system being designed to a predetermined temperature and humidity control. All the public rooms have individual thermostatic control and the first-class, senior officers' and engineer officers' accommodation is equipped with thermostatic control and separate air supply control. Individual manual temperature and air supply controls are fitted in the tourist and the remainder of the officers' cabins, while block control has been adopted for the crew spaces. To assist the effectiveness of the air conditioning of the ship the steelwork has been lined with insulating material.

Staterooms for the first-class passengers occupy the 'midship length of "A" deck, and all have a separate bath, or shower, and toilet. There are a number of suites and semi-suites, the remainder being single and double-berth rooms. Panelling of the rooms is based upon three basic schemes using various combinations of several woods, including maple, sycamore, walnut, pear, cherry, ash, birch, mahogany and others, for walls and furniture.

Tourist rooms are located at the forward and aft ends of "A" deck, on "B" deck and also forward and aft on "C" deck. The cabins have two or four berths, those on "A" deck all having a separate shower. Altogether, five schemes of decoration have been adopted for these rooms using hardwood and veneers in ash, sycamore, elm, walnut and cherry for the furniture, and paintwork in pastel shades and "Warerite" for the walls. The latter material with metal trim lines the showers.

The main public rooms for both classes of passengers are on the promenade deck, with those for the first-class passengers, consisting of drawing-room, club room, garden lounge and library, being situated right forward. Double doors in a curved bulkhead, which embodies glazing having etched wheel-cut patterns, open forward from a lobby into the crescent-shaped drawing-room. This has an all-over carpet, walls in arbele veneer, settees, easy and tub chairs covered in fabric in pale colours all of which combine to give a modernised impression of the Regency period. Doors to port and starboard lead forward into the club room, which has walls of straight grained olive ash relieved with arbele burr, which form a background for prints of Canadian and English sporting and country life scenes, by Archibald Forbes, each being hung against panels of maroon leather. This material in quilted form covers the bar front. The curved after bulkhead is decorated with four limetree panels, carved by Peter Hand, representing the four seasons, and also glass work with finely etched wheel-cut patterns.

Between the club room and the ship's side and the forward end of the deck-house is the garden lounge, which has walls of teak and plastic, having a formal plant and flower decoration, a trellis pattern ceiling, a tiled floor and garden furniture. On the starboard side of the deck-house and aft of the lobby is the library, where the walls are of Queensland walnut veneer and blue hide quilting, and there is blue all-over carpet on the floor, while the occasional chairs are in black leather piped with grey. The corresponding space on the port side is the children's playroom, which has a rubber-tiled floor, plastic walls with sycamore trim, with murals on a circus theme by Jan Bruce.

On the boat deck over is a sun lounge equipped with plastic topped tables and reclining chairs, and decorated with a map of the estuary of the St. Lawrence on the plastic wall covering. Sloping glazed windows look out on to the sun deck, which is enclosed with fixed steel and glass side screens.

From the first-class lobby on the promenade deck revolving doors to port and starboard give access to a short length of enclosed promenade space, which can also be entered from the garden lounge, and two passageways lead aft to the Empress Room. This room is available for both classes of passengers and is designed around a circular ceiling layout. There are bowed windows on each side and a dais surrounds the circular dance floor from which it is separated by metal railings. Sycamore and madrona burr with peroba panelling have been used for the walls, the curved portions at the aft end being decorated by marquetry vignettes by Margot Cragg, while the central dome worked with signs of the Zodiac is by Fleischmann. There is an informal arrangement of settees, easy and stuffed back chairs, all upholstered in bright colours, and a recess, flanked by mirrors, for an orchestra.

Double-glazed swing doors at the aft end of the empress room face similar doors on the other side of a cross passage, which open on to the tourist smoking-room. Here the panelling is in smokey-grey Canadian elm and the walnut furniture is covered in olive green and terra cotta leather, while the floor covering gives the effect of grey stone flags and is relieved by buff patterned rugs. Mr. J. A. Coleman was responsible for the mural panels which decorate the room and which interpret scenes from the lives of early Scotch and French explorers in Canada. Opening off the smoking room is the cocktail bar, which is panelled in Canadian elm and Pacific walnut and has a main decoration consisting of a map of Canada, the Atlantic Ocean and Northern Europe, and the coats of arms of the ten Canadian provinces by Warwick Lendon.

Continuing aft there is the spacious tourist lounge, with its walls of sycamore and cherry veneers, natural mahogany furniture, mainly upholstered in emerald and black, and an all-over carpet. Inset mirror panels and four paintings of garden and wild fruits and flowers form the main decoration, while at the after end of the room is a low marble and brick fireplace surrounded by burr wood and bronze. A short passageway to port leads aft to the writing room with its fitted leather-topped desks, avoudire and myrtle veneered walls, black and olive carpet and hide-covered chairs. A similar passage to starboard leads to the library, which has mahogany furniture upholstered in leather in pastel shades and walls veneered in prima vera and cherry. Double swing doors from both these rooms open on to wing lobbies which give access to the cinema, which is for the use of both first and tourist-class passengers,

Empress room which is available for both classes of passengers

CANADIAN PACIFIC LINER "EMPRESS OF BRITAIN"

Tourist smoking room

Tourist restaurant on "C" deck

Tourist library

Tourist lounge

and is equipped with two 35mm and one 16mm projectors. Deep maroon simulated hide covers the walls and is surmounted by mosaic acoustical tile, and the seats are of a new pattern which are silent in action. The tourist children's playroom is located to starboard on " B " deck and on the walls are pictorial murals by Jan Bruce, ranging from far-western to river estuary scenes.

Restaurants for both classes of passengers are situated on " C " deck, that for the first-class passengers being forward of the galley and the other being aft. Ash and maple veneers have been used for the walls of the first-class restaurant and there are murals of Canadian birds and flora by Cameron Baillie, flanked by concave panelling, and also mirrors and etched cut glass panels by Nan Ellson. There is a wall-to-wall rose and grey carpet and the sycamore chairs are upholstered in matching leathers. The tourist restaurant extends for the full width of the ship and has wall veneers of quilted Canadian maple and walnut with bandings of African elm and contrasting light-toned mural panels by R. D. N. Robertson, based on old engravings of Quebec, Liverpool, Ottawa, London and St. John. Linoleum covers the floor and the chairs are upholstered in blue-grey and on either side, at the after end of the room, are raised annexes which are separated from the main restaurant by low balustrades. Another amenity common to both first-class and tourist passengers is the swimming pool, measuring 25ft by 20ft and equipped with anti-surge recesses, on " D " deck, immediately below the first-class restaurant. Marble panels embodying murals, in grey-blue, illustrating the north and south banks of the St. Lawrence are at the sides of the pool and a translucent figure in plastic and aluminium, by Fleischmann, at one end. Raised side platforms are furnished with plastic-topped tables and deck chairs.

For the tourist passengers there are enclosed promenades to port and starboard of the public rooms on the promenade deck, with further open spaces aft, and at the aft end of the boat and " A " decks. The enclosed promenade spaces for first and tourist-class passengers have " Beclawat " three-panel windows at the ship's side which give an unrestricted view whether sitting or standing. Some of the public rooms are shown in the photographs which we reproduce.

The captain and staff commander have suites on the captain's bridge and the cabins of the deck officers, together with their ward room, are located in the house at the forward end of the boat deck, while all the engineer officers have their cabins, ward room and mess in a separate house further aft on the same deck. Cabins for the crew are situated forward and aft on " B " and " C " decks and on " D " deck, and are mainly arranged with two, four or six berths. Separate messes for the various engine-room and deck departments, petty officers and catering staffs are located on " D " deck forward of the boiler casings, together with a separate kitchen and pantry, and at the forward end of " A " deck there is a recreation room and shop.

" Warerite " decorative laminated plastics have been extensively used throughout the ship and the fire-resistant material " Marinite " besides being employed at all " A " class divisions and at stairways, has been used as divisional bulkheading in a block of tourist cabins. Twin-tube cold-cathode lighting, for the public rooms, and the closed circuit fire alarm system has been provided by the General Electric Company, Ltd., while Philips fluorescent lighting, operating on 220V d.c. current, has also been fitted in the state rooms, officers' and crew's cabins. Three Mawdsley's 120kVA motor alternators provide power for the cold-cathode lighting installation and for other units requiring an a.c. supply.

Auxiliary Equipment for Ship and Hotel Services

A generous amount of space is occupied by the galley and the various service rooms, the equipping of which has been largely the responsibility of Henry Wilson and Co., Ltd. Thermotank, Ltd., has supplied the air-conditioning system, which serves the whole of the passenger and crew accommodation, public rooms, restaurants and hospitals, and the necessary refrigerating plant, manufactured by J. and E. Hall, Ltd., consists of four " Veebloc " eight-cylinder, 7in by 5½in compressors, each powered by a 210 b.h.p. Laurence Scott electrical motor, and capable of dealing with a total of 9,000,000 B.Th.U. per hour. This company has also supplied the refrigeration machinery for the 78,000 cubic feet of insulated cargo spaces, and this consists of three twin-cylinder, 7½in by 6in compressors, each driven by a 42 h.p. motor and located in the shaft tunnel. One unit of the same size serves the domestic refrigerated chambers and, in addition, there is a deep freeze machine. Freon 12 is the refrigerant used throughout.

In addition to the main stairways linking the various decks there are four passenger lifts. One of them is for the first-class passengers, travelling from the swimming pool lobby on " D " deck to the sun lounge on the boat deck. Two of the lifts serving the tourist-class passengers are sited aft, one to port and one to starboard, and both connect the restaurant foyer on " C " deck with the promenade deck, while the fourth lift, which is located forward and to starboard, links the cabins on " C " and " B " decks with the tourist entrance hall on " A " deck. For handling baggage there is a lift forward to port ; this rises from the baggage room on " E " deck to the promenade deck. In addition to the above, the engineers have a lift which takes them from the engine-room to their quarters on the boat deck. Other lifts are concerned with the ship's services, there being two connecting all decks from " C " to the boat deck, another rising from " C " to the promenade deck, and a stores lift serving the galley on " C " deck. All the lifts are of Waygood Otis manufacture.

The disposition of the cargo holds has been mentioned earlier. Holds Nos. 4 and 5 have twin hatches and trunks and all are served by 5-ton derricks with the exception of No. 2, where 10-ton derricks are fitted. The derricks are mounted on derrick posts, two pairs being placed forward and two aft. MacGregor patent steel covers have been supplied to all weather deck hatches, together with covers of special design at each 'tween deck level in No. 2 hatch. For operating the derricks there are twelve Laurence Scott winches, each rated to lift 3 tons at 150ft per minute or 5 tons at 90ft per minute. Other deck machinery has been provided by Clarke Chapman and Co., Ltd., and includes two combined cable lifting and warping capstans driven through spur and bevel gearing by electric motors located in a separate compartment on " B " deck. Each cable lifter can exert a pull of 35 tons at 50ft per minute. Two warping capstans, with machinery below deck, are located forward and two more are placed aft, and all are rated to pull 18 tons at 50ft per minute. The after pair of capstans have motors mounted inside a deck-house and each motor is arranged to drive the cable lifting gear, which is capable of exerting a pull of 15 tons at 50ft per minute and is fitted to handle the stern anchor. This weighs 77 cwt and has been supplied, together with three 140 cwt forged stockless bower anchors and " Tayco " stud link chain cable by Samuel Taylor and Sons, Ltd.

Hugh McLean and Sons, Ltd., has supplied the lifeboats, all of which are constructed of the aluminium alloy " Birmabright." The complement consists of eight 36ft boats, having a capacity of 146 persons ; one 36ft class " A " motor lifeboat to carry 132 persons, and one class " B " motor lifeboat to accommodate 136 persons, and two 26ft emergency boats to carry 46 persons. Thornycroft engines are fitted in the motorboats, the remainder being fitted with Fleming hand-propelling gear and all the lifeboats are carried in Welin-Maclachlan overhead gravity davits, the boat winches being powered by Laurence Scott electric motors.

" Telemotor " controlled steering gear operates the streamlined semi-balanced rudder and consists of two power units and four cylinders, which are interconnected so that five combinations of cylinders are possible with both the variable delivery pumps, each being direct coupled to a 45 h.p. electric motor, running together or separately. One power unit can move the rudder from hard-over to hard-over—that is through 70 deg.—with the ship moving at full speed ahead in forty-five seconds. This time is reduced to twenty-five seconds with both power units in operation.

Standards of passenger comfort have made stabilisers an almost essential piece of equipment in liners and besides providing the steering gear, Brown Brothers and Co., Ltd., has supplied the ship with a set of Denny-Brown stabilisers. The gear is housed in a compartment on the tank top forward of the auxiliary machinery space, and the retractable fins each have an outreach of 12ft by a fore-and-aft length of 6ft 6in, giving an area of 78 square feet. They can be extended in 150 seconds and withdrawn into the hull in 100 seconds, and with the ship moving at 20½ knots each fin when tilted to 20 deg. exerts a lift of 61 tons to give to the ship a righting moment of 5400 tons-feet. To deal with sewage the ship is fitted with five sets of Drysdale twin pump " Contra-Siphon " expulsion plant.

Experience has made the owning company fire conscious and the ship is fitted out in excess of the Ministry of Transport and Convention requirements. Mention has already been made of the extensive use of " Marinite " and the subdivision into fireproof zones, and, in addition, there is a Grinnell automatic sprinkler and alarm system throughout the passenger accommodation. Besides the wheelhouse there are two complete fire control stations, each able to be in constant contact with any part of the ship. In the cargo holds, which have mechanical ventilation supplied by the Winsor Engineering Company, Ltd., there is a Pyrene CO_2 system, while in the machinery spaces a separate CO_2 installation having high and low-level supplies is fitted.

A total of seventeen electrically operated horizontal sliding watertight doors have been supplied by Donkin Ltd., and are controlled from the bridge, the bulkhead deck and locally.

Pye Marine, Ltd., supplied the emergency loud-speaker system and also extensive sound reproduction system, which is fitted in all the public rooms, officers' ward rooms and the crew's recreation and mess rooms. For transacting the ship's business there is a 100-line automatic telephone exchange.

Chadburn's " Synchrostep " telegraphs for the engine-room, steering gear and anchor are installed, and the navigation aids include Marconi wireless telegraphy equipment, a " Decca " radar installation and navigator, while Kelvin and Hughes, Ltd., has provided compasses, an echo sounder, a Ralston stability and trim indicator and " Pneumercator " gauges for the tanks.

(To be continued)

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

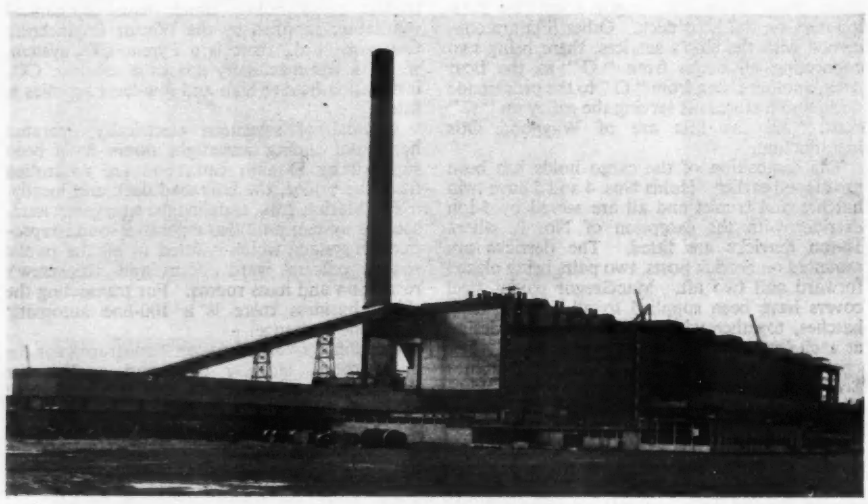
GRAPHICAL SYMBOLS FOR HEATING AND VENTILATION INSTALLATIONS

No. 1553, Part 4 : 1956. Price 3s. 6d. Graphical symbols are used extensively in the heating and ventilating industry and the symbols shown are based on what is considered to be the best British practice. The main use for such symbols is for plans for installations which are drawn on to architects' plans of buildings or of ships. Although this is the normal use for which the symbols in this standard are intended they can also be used for schematic diagrams and for isometric drawings. The symbols do not attempt to show all the detail which must in any case be given in a specification ; for example, the type and method of operation of a valve. The symbols can, however, be used in combination to give a complete layout plan of the most complicated installations. The standard is divided into six sections ; the first four sections deal with heating and hot water supply ; the last two sections deal with ventilating, air conditioning, dust and fume exhausting. The section for boiler, pump and plant house equipment is supplemented by eight typical diagrammatic drawings showing how boiler-house equipment can be indicated in connection with heating and ventilating drawings using the standard symbols. In the section for ventilating and air-conditioning equipment there is a similar sub-section in which four diagrammatic drawings are given. The committee responsible for this standard have given much attention to the general conventions and symbols used for pipework and duct work respectively, and it is expected that considerable benefits will result from the adoption of standard practice. A complete index of symbols is included.

Marchwood Power Station

The Marchwood power station, on which construction began in 1952 and of which the foundation stone was laid in September, 1954, started producing electricity towards the end of 1955. Building progress is outlined and reference is made to the use of aluminium and glass cladding in the construction of the main buildings.

WE were recently able to pay a brief visit to the Marchwood power station, which is under construction on a 144-acre site on the south bank of the River Test and facing the ocean liner quay at Southampton. This station is the first on the South Coast to be entirely planned and constructed by the Central Electricity Authority. Operations on the site began in August, 1952, and a brief description of the civil engineering work, together with an illustration of the site, appeared in our issue of January 8, 1954. Later the same year, in our issue of September 17th, we noted that the foundation stone was laid on September 8th and gave a general description of the site preparation, of the piling to take the foundations of the main buildings, which are steel framed. In the article main particulars were given of the boiler installation, the hydrogen cooled turbo-alternators, the coal-handling plant, the oil-handling plant, water preparation plant, switchgear, and auxiliary equipment.



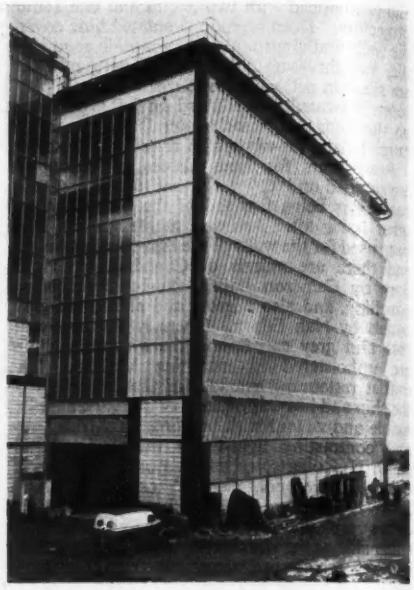
Marchwood station from the east, the buildings from left to right being workshop and stores, boiler-house, turbine house and part of administration block

Since our last visit nearly two years ago,, considerable progress has been made and the first of eight 60MW generating sets began producing electricity at the end of 1955. The remaining generating units, many of which are at an advanced stage of construction, will come on commercial load at intervals until the station is at its maximum capacity of 480MW. The coal wharf, with its 10-ton portable grabbing cranes, and the coal-handling plant with its twin-belt conveyor system, each belt having a capacity of 300 tons per hour, are complete, although not in use, since the station is operating on oil fuel. This is boiler oil, having a viscosity of 6000 seconds Redwood 1, for the storing of which there are three tanks having a total capacity of 10,000 tons, the oil being pumped through lagged and steam traced pipelines.

All the main buildings are well forward and the turbine house, which is 109ft wide by 97ft high and will be 600ft long when completed, is equipped with a crane, supplied by Sir William Arrol and Co., Ltd., having a 105ft span and designed to lift 160 tons, the auxiliary lift being 30 tons. The other crane, manufactured by Stothert and Pitt, Ltd., has the same span and can lift 45 tons with an auxiliary lift of 10 tons. The boiler and air heater bays measure 520ft long by 88ft wide by 127ft 6in high, and the bunker bay 600ft by 34ft by 117ft 6in, while the corresponding dimensions of the pump bay are 520ft by 33ft 6in by 97ft. The Wharton Crane and Hoist Company, Ltd., manufactured the 15-ton crane in the pump house, and the 10-ton crane in the workshop was provided by Reed Brothers (Engineering), Ltd. One of the 425ft high reinforced concrete chimneys is complete and the construction of the second is well advanced. To deal with the circulating water there are eight Drysdale 55,000 gallons per minute pumps, each of which takes its suction through vertical rotating band screens. Five 250 lb per hour intermittent dosing chlorinating plants treat the circulating water, which is delivered to, and discharged from, the condensers via twin 8ft square reinforced concrete culverts.

During the last thirty years there has been a considerable change in the external appearance of electricity stations, and the purely industrial exterior has given way to architect designed brick structures. Some stations have been designed on the outdoor principle, as adopted for oil refineries, while others, notably at Willington, near Derby, and Ince, Ellesmere Port, have the boiler plant unenclosed. At Marchwood the architects, Messrs. Farmer and Dark, have adopted steel frame construction covered with light cladding in association with glass. Aluminium was adopted for the cladding and provides, at about 1 lb per square foot, an in-filling which is exceptionally light in weight. As no painting is required, there is a considerable saving in maintenance costs. Our first illustration gives a view of the station and shows the state of progress.

Aygee Ltd. was responsible for the cladding and glazing and this involved the development of new sections, in which work they received the assistance of the Research Department of the British Aluminium Company, Ltd., the company supplying the alumi-

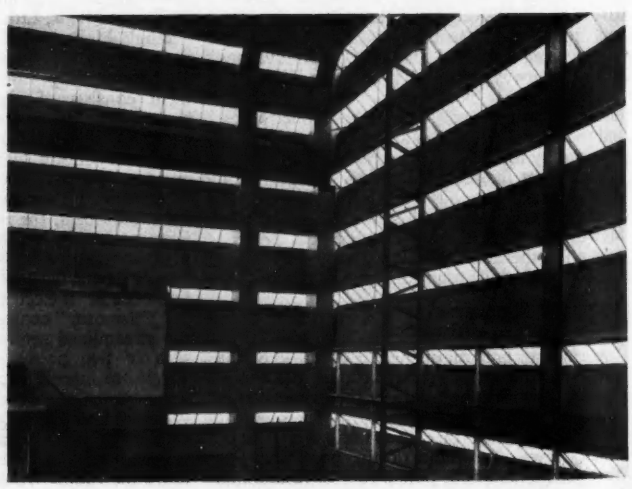


South-east end of turbine house showing saw tooth arrangement of cladding on end wall and vertical cladding on side wall

nium. Commercial purity aluminium has been used for flashings and duct covers, NS3 alloy for other sheet material and H.E.9 alloy for extrusions and glazing bars, involving a total of about 80 tons of aluminium and aluminium alloys.

Most of the cladding on the boiler house and turbine house is of 18 s.w.g. sheet, formed into rectangular corrugations, 2in deep and 9¾in wide, on a press brake. This corrugated sheet has, in general, been applied vertically, but in the end walls and the long side of the turbine house the sheet, in association with glazing, forms a saw tooth pattern, as shown in our illustrations which give inside and outside views. On the workshop and stores building the auxiliary boiler house, the cooling water pump house, and elsewhere the cladding consists of 18 s.w.g. standard "Rigidal Industrial Trough T" corrugated aluminium sheet. This form of sheeting has also been used by Freeman, Morrison, Ltd., for the roof and side cladding of the coal conveyors and sides of the junction towers.

Fire-resisting "Asbestolux" panels, ¼in thick, have been used to back the special profile sheets, which were arranged for unit construction, forming the cladding to the main buildings with "Gyproc" aluminium-foil-faced plaster board being used to line the workshop and stores building. At points where glazing is employed extruded sections, 4in deep and spaced 3ft 3in apart, form the vertical modules, which are

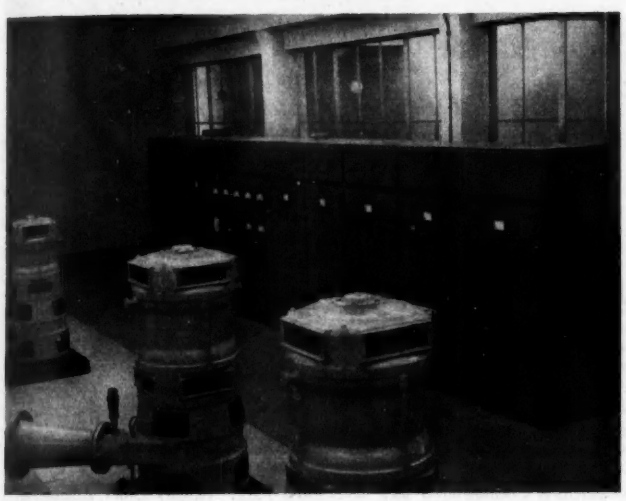


Internal view of saw tooth arrangement of cladding

backed by steel flat bars. For the roof of the power house and some of the auxiliary buildings Briggs aluminium decking has been used. Each of the three oil tanks is 88ft in diameter by 25ft high. Since the oil has to be maintained at about 123 deg. Fah. in order to facilitate pumping it is essential to keep heat losses at a minimum in the interests of steam economy. Accordingly the tanks have been insulated by William Kenyon and Sons, Ltd., with 2in thick slabs of medium density "Rocksil," and weather protection for this is provided by 22 s.w.g. "Rigidal" 3in pitch corrugated aluminium sheeting.

Automatic Pumping Control at the Chew Valley Scheme

CHEW STOKE reservoir, which lies at the foot of the Mendips, about 10 miles south-west of Bristol, was inaugurated on April 17th by Her Majesty the Queen. The reservoir and its associated system of pumps and mains, has been built for the Bristol Waterworks Company, the consulting engineers for the reservoir being Messrs. T. and C. Hawksley, and the main contractor A. E. Farr, Ltd. A storage capacity of 4500 m.g. is provided by the reservoir, and water is pumped from it, either through the Barrow pumping installation, which delivers raw water in bulk to the open service reservoirs at Bristol at a head of 170ft, or through the Stowey pumping installations. The latter deliver, at a head of 150ft, to a ¼ m.g. reservoir at Stowey, where an activated silica treatment plant has been built. The treated water is then pumped in three directions: to the southern edge of Bristol, to Bath, and to the neighbouring West Gloucester Water Board. Automatic control is employed for the pumps of the Stowey system. This electrical control system which is described more fully in a later paragraph, was the responsibility of the Igranic Electric Company, Ltd.



Pumps and control board for the Stowey pumping service. The seven-stage receivers and additional water level indicator are mounted on the main panel

Chew Stoke reservoir is formed by an embankment with a maximum height of about 40ft, and with a clay puddle core. The main interest of this embankment lies in the use of sand drains to relieve pore water pressures set up during construction in a layer of soft material beneath the dam. This work has been described by Skempton and Bishop in a paper at the Fifth Congress on Large Dams; a cross section of the embankment, and a brief account of the use of the sand drains was given in our issue of June 17th 1955, page 851, when the congress papers were reviewed.

Barrow Pumping System

A penstock regulates flow from the reservoir to the pump house, which is situated below the embankment. In the pump house the incoming main divides to feed the two pump installations.

The Barrow service consists of five Harland pumps, four of 4 m.g.d. and one of 2 m.g.d. capacity. They are controlled by Ellison hand-operated auto transformer starters. A non-return reflux valve and hand-operated sluice valve are fitted between each pump and the common 36in delivery main.

Stowey Pumping System

The Stowey service consists of four Harland pumps feeding a common 24in delivery main through individual Glenfield and Kennedy non-return reflux valves and motor-operated "Rotork" sluice valves.

The Stowey section is operated entirely automatically, its purpose being to regulate the starting and stopping of the four pumps, so as to maintain at normal the level of the water in the Stowey raw water reservoir. When this level falls below normal, one or more of the pumps will start up. This control is achieved in seven separate stages, dependent on the water level.

The four pumps are driven by squirrel-cage motors and are designed to deliver, respectively, at the rate of 1, 2, 3 and 3 m.g.d.; they are powered at 45 h.p., 87 h.p., 110 h.p. and 110 h.p., respectively. The stages are arranged to start at 1 m.g.d. and increase as the level drops in steps of 1 m.g.d. to give the following combinations:

Stage	Operating h.p.	Starts	Stops	Rate of flow, m.g.d.
1	45	Pump No. 1	—	1
2	87	Pump No. 2	Pump No. 1	2
3	110	Pump No. 3	Pump No. 2	3
4	155	Pump No. 1	—	3+1
5	197	Pump No. 2	Pump No. 1	3+2
6	220	Pump No. 4	Pump No. 2	3+3
7	265	Pump No. 1	—	3+3+1

The selection of each stage is controlled by a float-operated Evershed and Vignoles electronic transmitter fitted in the Stowey reservoir. This is connected to the seven-stage receivers mounted in the centre of the control panel, by an eight-core underground cable. These receivers are of the "follow the pointer" system and are each equipped with adjustable maximum and minimum contacts so that the cut-in and-out levels can be varied. An additional receiver of the "Cirscale" type is provided to give a continuous indication of reservoir water level.

If the water level drops to call in the first stage, the contacts in the No. 1 receiver close to start No. 1 pump motor, switching it direct-to-line. After a short pause, to give the motor time to reach full speed, a timer operates to start, in slow speed, the motorised delivery sluice valve. The motor is permitted to run up to speed before taking the load to ensure the valve is "snatched" off its seating. Once "cracked" the two-speed valve motor is reconnected in high speed and it quickly runs to its open limit. The flow of water opens the non-return reflux valve and the set continues to run until the signal to close down is received.

On shutting down, the sequence is reversed, the pump remains running and the valve is closed first. The valve closes at high speed, dropping to slow speed to complete its run in. It is finally stopped on a torque limit switch which is arranged to operate mechanically when the load is built up by the valve faces sealing. The pump shuts down automatically when the valve has closed. Indicator lights on the pump control panels show the open/close positions of the valve and whether the pumps are operative or not. Tryout switches are also mounted on the pump panel doors to permit hand control of valve and pump motors. The valves can also be opened by turn-key. A third tryout switch controls the pump motor heaters, which are automatically switched off when the pump starts.

If No. 1 pump were shut down when the level was still falling, stage 2 receiver would operate to close down this pump and at the same time would bring in No. 2 pump in a similar manner to that described above. In this way the rate of pumping is gradually increased until the supply overcomes the demand at which point the rate is maintained until the high level is again reached.

As this station is unattended at night, various safety precautions have been installed, together with an elaborate alarm system. The safety precautions include automatic shut down of all pumps in the event of failure of supply to transmitter, a fault on the underground cable, or a burst main. A mains burst will drop out a pressure switch, the contacts of which are controlled by a timer to differentiate from normal surging peaks. Shut down of individual pumps will occur on phase failure or low volts on the pump or no-flow within a prescribed time limit after the start signal is received. No-flow protection is achieved by a switch operated by the reflux valve and these contacts must close to indicate a flow within thirty seconds of the pump being started. If the shut-down affects only one pump the next stage will come in automatically when the water has dropped to the next level. Any of the faults indicated above will shut down the set in the correct manner, valve first and then pump. Low volts or phase failure on pump motor will, of course, shut it down at once and the valve on these occasions will close last.

The alarm system consists of five units; one for each of the three staff dwelling-houses; one in the station and one at Stowey. Each unit consists of an alarm bell, indicating light and a bell cancellation push-button. Of the house alarms only one can ring and the "on duty" one is selected before leaving the station at night. The alarms are sounded if any of the faults described above occur and as they are fed by a 50V battery they will also give warning if the power has failed. In this event the emergency lighting is automatically switched in.

Indicators are included on the centre panel to show which stage is running; lights which indicate on an alarm, the pump affected, or show whether the fault lies in circuit from the transmitter. A test button or selector switch is mounted close by so that these indicator lights, together withthe alarm, can be tested. A plug board is included so that the duties of the two 110 h.p. pumps can be interchanged.

All pump starters and receivers are housed separately for isolation. The size of each cubicle is similar so that they can be bolted together to form a continuous board, as illustrated. At the extreme left a circuit breaker and distribution boards are included for handling all the auxiliary services associated with the station.

Two 11kV overhead feeders supply the station. These are brought in underground to their h.t. circuit breakers sited in a separate room. These breakers are mechanically interlocked and the water company has the authority to change over feeders when necessary. After metering the single incoming cable is fed through the house breaker to a 900kVA oil-cooled transformer, where it is stepped down to a 415V, three-phase, four-wire system. Push-buttons are mounted at key points in the pump room to trip the house breaker in an emergency.

138kV Submarine Power Cable for Vancouver

LAST week we visited the Trafford Park works of British Insulated Callender's Cables, Ltd., to see the 138kV submarine power cable which is being loaded in the cable ship "Ocean Layer" preparatory to laying between Vancouver Island and the mainland of British Columbia.

It will be recalled that, in February, 1954, British Insulated Callender's Cables, Ltd., announced the receipt of an order worth over 3,000,000 dollars from the British Columbia Electric Company for the supply and installation of about 77 miles of 138kV gas pressure cable. This cable was to be laid across the Georgia Strait for the transmission of power from the mainland to Vancouver. The circuit, consisting of four single-core cables, one being a reserve, was to be capable of transmitting about 110MW.

The first stage of the contract, the design and manufacture of the cable in continuous lengths of about 16 miles each, has now been completed. The cable was made by British Insulated Callender's (Submarine Cables), Ltd., in the company's Trafford Park works. To allow for manufacture in long, continuous lengths, pre-impregnation was used for this gas pressure cable, which differs in some ways from the cable used in 1953 in full-scale trials for the England-to-France cross channel project.* The Vancouver cable has a hollow conductor to provide the gas channel, the under-sheath clearance being eliminated. At the maximum depth of the crossing (about 100 fathoms) the water pressure reaches about 270 lb per square inch. Accordingly, to preserve a positive margin of internal pressure at all depths, a charging pressure of 300 lb per square inch was adopted for the nitrogen gas filling. The cable has a lead-alloy sheath and special anti-corrosive protection and armouring with galvanised steel wire in preference to aluminium alloy wire.† The finished cable has an overall diameter of 4in and a weight of about 50 lb per yard.

Since drums were impracticable for the lengths and weights of cables involved, special arrangements were made for the loading, transport and storage of this cable prior to shipment. From the factory to the dockside a power-operated gantry system was built. It crosses the Trafford Park Road at a height of 45ft and extends for a total length of 1100ft to the quay where the gantry proper terminates on a tower 120ft from the edge of the quayside. From here two swivel beams, which can be swung through a small arc on rails mounted on a cross gantry, provide twin cable-runs directly above the holds of the cable ship.

To store the cable between manufacture and loading a steel-clad coiling-down shed was built directly below a section of the gantry. This shed is 350ft long, 74ft wide and has a height of 43ft 6in to the ridge. It provides an unobstructed floor area of about 20,000 square feet for cable storage and allows five cable stacks each with a diameter of up to 60ft, as illustrated here.

On the gantry above the coiling-down shed a pair of light rails form a track for two sheave-winches which, as illustrated, are mounted on skids and can be moved into position over any of the five coiling positions. With the cable-laying ship alongside, a caterpillar winch mounted on the gantry pulls the cable from its coil in the shed over a quadrant at gantry level and along the gantry to the winch, then pushes it along one of the swivel beams so that it can be lowered and coiled into the ship's hold directly below. Telephone communication is maintained between quayside, winch positions and each coiling bay in the shed during loading and coiling operations. Heaters are installed at intervals along the wall of the coiling-down shed to keep an even temperature.

The 4600-ton cable-laying ship "Ocean Layer," which is owned by Submarine Cables, Ltd., is chartered for this contract and during our visit last week we were able to see the operation of winching the cable from the coiling-down shed into the ship's hold. The "Ocean Layer" is a single-screw ship which was built in 1948 and recently converted to a cable-laying ship. An important part of the conversion was the fitting of a Pleuger active rudder, which consists essentially of an auxiliary propeller housed in the pear-shaped rudder blade, greatly increasing the ship's manœuvrability. The ship has a service speed of 11 knots and is equipped with modern navigational aids, including "Decca" navigator and "Loran" and Kelvin and Hughes echo-sounders, up to 5000 fathoms.

There are four cable tanks (two being aft of the engine-room), with a total storage capacity of 76,809 cubic feet. Bow sheaves of 7ft diameter are installed for picking up and paying out cable. Above these sheaves is an overhead gantry of 2-ton lifting capacity for handling repeaters, a facility which is required for some communications cables. Near this gantry are the engine-room telegraphs, steering and active-rudder telegraphs for use when controlling the ship from the bows. On the deck, aft of the repeater gantry, are the cable engines, equipped with 9ft 6in diameter drum and V.S.G. braking gear, the draw-off and holding-back gear and the load-cell dynamometers.

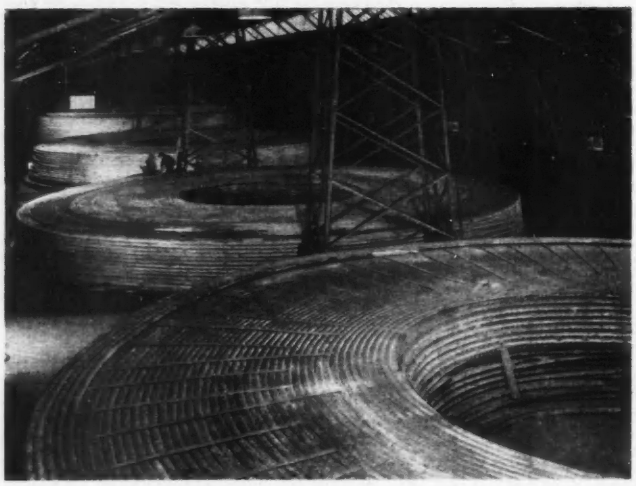
Over the stern there is an after paying-out sheave of 7ft diameter and immediately aft of the superstructure is the caterpillar gear which incorporates a load-cell dynamometer and is capable of paying out aft, cable equipped with rigid repeaters.

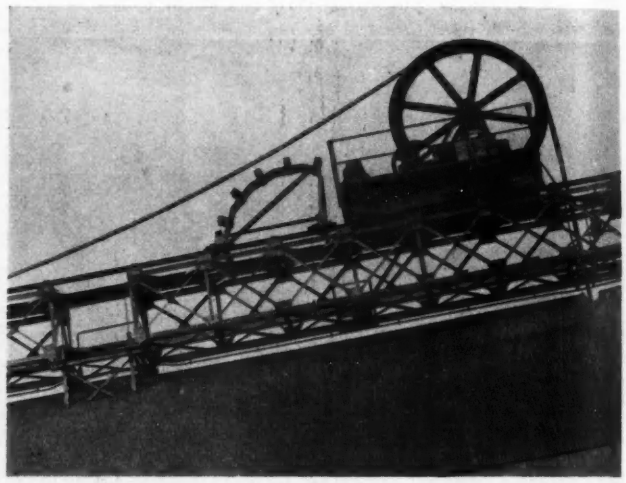
A drum room for controlling pay-out of cable and a separate air conditioned test room for a.c. and d.c. cable testing are housed at main deck level in the forward part of the superstructure, on the port side. The drum room is equipped with instruments showing the amount of cable paid out and giving dynamometer readings and an indication of slack. Repeaters, receiving dynamometer and "slackometer" readings from the drum room, are installed on the bridge.

The total weight of the Vancouver submarine cable being loaded is over 3800 tons, and when loading is complete this ship will sail for Vancouver via the Panama Canal, taking some forty days for the voyage.

The submarine cable route, determined by extensive marine surveys carried out during 1953/4, is from a point on the mainland south of Greater Vancouver and close to the mouth of Fraser River, under Georgia Strait, to an intermediate island, then under Trincomali Channel to Saltspring Island, where it will be linked with the existing high-voltage overhead transmission network. The cable system will consist of single-core cables, each approximately 16 miles in length, and similar cables each about 3½ miles long for the inter-island section.

The cable-laying operations in Georgia Strait, Vancouver, will be followed by completion of the terminations at the appropriate shore sites and by testing of the whole installation. It is expected that the complete submarine power cable link will be in operation in September. The installation and associated work is the responsibility of British Insulated Callender's Construction Company, Ltd.





(Left) Four of the five 16-mile lengths of submarine cable for Vancouver in the manufacturer's coiling-down shed at Trafford Park. (Right) 138kV submarine power cable passing over a sheave-winch into one of the bays in the coiling-down shed

* "The Possibilities of a Cross Channel Power Link between the British and French Supply System," D. P. Sayers, M. E. Laborde and F. J. Lane *Proceedings I.E.E.*, Vol. CI (I), pages 284–308.

† These details are abstracted from page 300, *loc. cit.*

TWO-STROKE POWER UNIT.—The 70 c.c. engine built by the Villiers Engineering Company, Ltd., Marston Road, Wolverhampton, is now available complete with fuel tank, exhaust system and mounting brackets. The engine is horizontal and appears very compact, the fuel tank curving closely over the crankcase. The demountable silencer runs across and below the cylinder, the air intake strainer and exhaust gas outlet being in propinquity. At 3000 r.p.m. the output is 0·55 b.h.p., the engine in this form being known as the Mark 5G.

Spot Welder for Brick Force Reinforcement Fabric

We illustrate an air-operated automatic spot welder for the quantity production of brick force reinforcement fabric as used to strengthen lintels and walls, &c., in buildings. This welding machine has been developed by Sciaky Electric Welding Machines, Ltd., Slough, Bucks.

The reinforcement fabric, which usually consists of two 10 S.W.G. steel main wires and 12 S.W.G. cross wires has hitherto been produced by fusion or single-head spot welders. To provide for increased output a special fixture was designed for attachment to a standard Sciaky high-speed air-operated spot welder, model "PMO," rated at 30kVA. Some thirty welding strokes a minute, totalling sixty welded joints, can be achieved by this equipment, which only requires supervision by an unskilled operator.

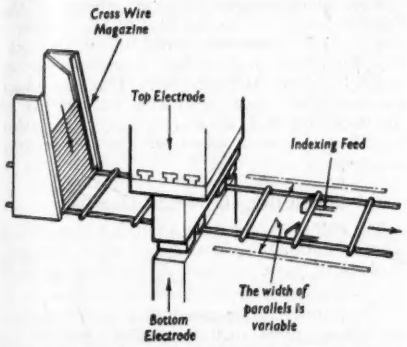


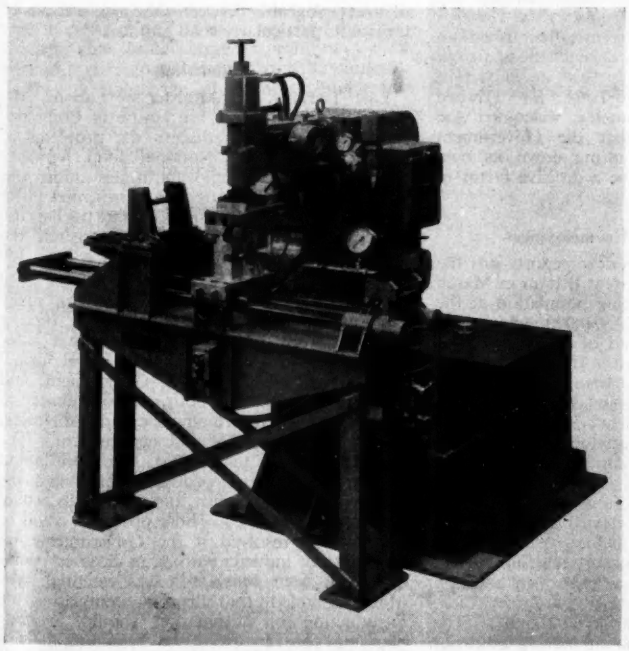
Diagram of automatic spot welder for production of wire reinforcement

Basically the fixture comprises a hydraulically operated shuttle mechanism for indexing the fabric through the machine at the correct cross-wire pitch; a magazine which automatically feeds the cross wires on to the shuttle mechanism; and water-cooled electrode dies which produce two welds simultaneously on the direct/parallel system of welding. Initially the main or longitudinal wires are fed through guides to the electrode position and the magazine is loaded with cross wires which have been previously straightened and cropped to length. The first set of joints in a production run are welded by a step-by-step arrangement, in order to pilot the automatic indexing system. After these wires are welded the machine continues to attach cross wires automatically to the main wires and idex the fabric at the required pitch as long as the material is fed to the machine. The brick force reinforcement is then wound on to spools for easy transportation or is sheared to short lengths.

The indexing stroke is developed by a double-acting hydraulic cylinder fed by a self-contained pump and tank unit attached to a base plate integral with the machine. The distance between cross wires, normally 12in, is adjustable by means of limit switches actuated by the travel of a spring-loaded pawl arrangement fitted on the right-hand side of the machine. Twin pawls engage on the previously welded wire, and draw the entire fabric through the machine by the required distance. The electrodes are manufactured from high-grade chrome-copper alloy, and are of the bar design with wedge adjustment which will accommodate main wires spaced at 2in, 3½in or 6in centres, without any alteration to the fixture. Adjustment is also available on the magazine to correspond with variations in fabric width. The timing circuit is fully interlocked electrically and the welding sequence is initiated by depression of a push button. To eliminate contactor maintenance ignitron tubes are used to switch the primary current.

The machine can apply an electrode force of 750 lb and needs to be connected to an air supply developing 70 lb to 80 lb per square inch line pressure.

Although the plant illustrated was designed for production of a specific type of wire reinforcement it could well be adjusted to produce other wire goods provided that the mesh dimensions are constant and the cross wires not less than 14 S.W.G. It is also a good example of how a standard machine with the addition of a relatively simple form of automation can, in certain circumstances, produce on a scale comparable to an expensive purpose-built multi-spot-welder.



Automatic air-operated spot welder for production of wire reinforcement

Pneumatically Operated Piston Valves

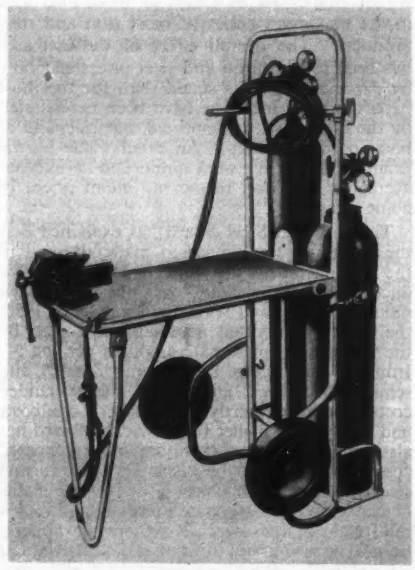
Pneumatic operating mechanism has been developed by Richard Klinger, Ltd., Sidcup, Kent, for the piston valves which it makes. These piston valves incorporate a ground and lapped piston sealed by two resilient packing rings separated by a ported lantern bush which is an easy fit in the valve body. When the valve is open flow is through the ported lantern bush and central orifice of the lower packing ring, and in this position only the top ring is in contact with the piston. To close the valve the piston is pushed down through the lantern bush into the lower packing ring.

Experience showed that the valves were frequently used as stop valves either in the fully open or fully closed positions, and for this reason the new air-operated valve is designed for two operating positions—fully closed or open. The valve is operated by a double-acting air cylinder mounted on columns fixed to the top flange of the body. A straight spindle connects the valve piston with the piston-rod of the air cylinder and adjacent or remote pneumatic control is provided by small hand or solenoid-operated valves or push buttons.

Pneumatic operating equipment is available for the standard range of Klinger piston valves from ¼in to 6in bore. The firm specifies a standard air operating pressure of 70 lb per square inch.

Mobile Welding Trolley

The accompanying illustration shows a mobile welding equipment which has been developed by Croftshaw (Engineers), Ltd., 523 Ordnance Road, Enfield Lock, Middlesex, for use in factories or on working sites. This equipment consists of a tubular framed trolley incorporating a 3ft. by 2ft welding bench, with a fitter's and pipe vice mounted at one end, and accommodation for oxygen and acetylene cylinders.



Welding trolley incorporating a bench and accommodation for gas cylinders

When the trolley is swung up on one end, as shown, the cylinder support bracket forms a firm base, and the outer end of the hinged steel plate-topped bench is supported by a tubular leg. When it is required to move the equipment the table is swung back against the underside of the trolley frame, where it is clipped in position. The trolley is then pulled over on to the 14in diameter pneumatic-tyred wheels, on which it can easily be moved using the top member of the tubular frame as a handle.

Pneumatic Brake Duplication

Building upon the experience gained with the Thornycroft "Mighty Antar," on which a dual brake valve controlled tractor and trailer brake systems together without sacrificing the independence of each from failure in the other, Clayton Dewandre Company, Ltd., has now developed a compact dual valve for normal vehicles with compressed air brake systems. The use of this valve allows two parts of the brake system—for instance, the front and rear axles—to be separate, so that any failure other than of the pedal itself does not completely nullify the foot brake. In order that all the air cannot be lost through a breach in any part of the system, the compressor charges, through non-return valves, two reservoirs, each feeding through one part of the dual valve. Each part consists of a disc and plunger valve resembling that illustrated on page 303 of our issue of August 26th last, the plungers being depressed by the ends of a symmetrical balance beam linked to the pedal. Since the two valve units are identical, equal pressures are supplied to each part of the system. By using different return springs under the valve pistons differing output pressures can be obtained, but experiments along these lines have led the manufacturers to believe that the advantages do not justify the ensuing service difficulties. However, the maximum pressure in either part of the system can be limited to a value below the pressure of the reservoirs by use of shims.

Surface Hardener for Concrete Floors.—A new product known as "Plycol" surface hardener has been introduced by British Bitumen Emulsions, Ltd. This material is not an additive to the concrete mix, but is applied as a surface treatment.

Industrial and Labour Notes

Iron and Steel Prices

At the end of last week the Iron and Steel Board announced increases, as from May 7th, in the maximum prices of most iron and steel products. The overall effect of the increases has been to raise iron and steel prices generally by 5 per cent. It is stated that, for the most part, the price increases have been necessitated by the higher cost of imported materials and of home-produced scrap. An order made by the Board of Trade last week authorised an increase averaging £2 a ton in the maximum prices of home scrap.

The Iron and Steel Board has explained that the landed cost of imported materials used in the manufacture of iron and finished steel products has risen steadily over the last fifteen months. Compared with the first half of 1955, the costs of imported materials have risen by the following approximate amounts per ton :— Iron ore, 11s.; scrap, £7 10s.; pig iron, £5, and semi-finished steel, £6. These higher landed costs have arisen partly from higher f.o.b. costs and partly from higher freights. The Board has also pointed out that there are other increased costs which have to be borne by the iron and steel industry, particularly as a result of the higher wage rates negotiated recently and higher rail freight charges which have come into operation. The new prices for iron and steel products do not reflect these increases which will, consequently, be carried by the industry. The Board says, however, that " the extent to which the industry will be able to continue to do so will be kept under review."

Even with these latest increases, the prices of iron and steel products in the United Kingdom market are still below those in most other steel-producing countries. In general, the differential is of the order of 10 per cent.

National Coal Board's Report

The National Coal Board's report for 1955, which was published at the end of last week, puts on record the fact that British coal mines last year produced 210,200,000 tons, which was 3,800,000 tons less than in 1954. The report says that most of the reduction occurred in the five-day week, although the output from voluntary working on Saturday was down by 44,000 tons. Last year's output from opencast sites was 11,400,000 tons, or 1,100,000 tons more than in 1954. Thus, last year's total saleable output of coal was 221,600,000 tons. The report explains that only two divisions, East Midlands and Northern, achieved significant increases in output last year. In the remaining divisions production was less than in 1954, and there were substantial falls in the Scottish, North Eastern and South Western divisions, where disputes caused particularly heavy losses. On the other hand, the report states, productivity at the coal face in 1955 averaged 65·5 cwt a manshift worked, the highest figure ever recorded for the country as a whole.

The financial statement shows that by the end of the year, the Board was faced with a deficit of £19,579,965, although its operations in the last quarter of the year resulted in a surplus on the revenue account of £9,175,199. Colliery profits, profits on opencast working, and profits of the Board's ancillary undertakings totalled £15,547,832, but that was reduced to £1,170,035 by the loss incurred on imported coal (£13,558,534), and provision for taxation. The interest payable to the Minister of Fuel and Power amounted, over the year, to £20,750,000. An analysis of the finances shows that the total cost of producing coal from the Board's mines last year was 67s. 3d. a ton, or 5s. 4d. a ton more than in 1954. Proceeds from the sale of coal, at 68s. a ton, were 4s. 6d. a ton more than in 1954, but the profit in 1955 (before charging interest), at 9d. a ton, was 10d. a ton less than in 1954.

Wages, Dividends and Inflation

The annual general meeting of the London Chamber of Commerce was held on Tuesday, May 1st. Sir Edward Chadwyck-Healey, Bt., was re-elected president for a second year of office.

In his presidential address, Sir Edward mentioned that during the past year inflation had at last been recognised as the major peril threatening the future of this country. It was, he said, in the interests of trade unionists as much as the rest of the community that prices should fall, but so long as wages and, therefore, prices, rose in one major industry it was human nature that the workers in others should also demand a rise. If all would refrain, all would be better off. The excuse of the trades unions for not facing this issue squarely, Sir Edward continued, was that companies were paying higher dividends on their risk capital. It was quite time, he suggested, that " there was a little plain speaking on this subject." There would be no industry at all and therefore no wages paid unless investors were prepared to risk their capital. Every year 4000 companies were liquidated. If investors were merely to be left with passed dividends or reduced dividends and had no set-offs from companies which increased them, who would be so foolish, Sir Edward asked, as to save money to invest it ? In any case, whereas wages had increased by 250 per cent since 1938, dividends had only increased 80 per cent in the same period, as was shown in the White Paper on *The Economic Implications of Full Employment*. But the main point, Sir Edward added, was that increased dividends, paid to a relatively few people, had an infinitesimal effect one way or the other on the problem of inflation, whereas increases in wages represented hundreds of millions of additional purchasing power per annum in the hands of the people. To talk about restraint in dividends as though that had any marked effect upon the inflationary position had no grounds in reason, Sir Edward remarked, but was purely emotional. The figures given in the White Paper showed clearly that the investor had had a very raw deal as compared with the wage earner.

Unless, Sir Edward went on to say, industry could earn substantial profits out of which to keep up to date in equipment and research, it would rapidly find itself driven out of overseas markets by its competitors. In order to have at its disposal that necessary annual surplus, industry must earn vastly more in order to pay a high proportion of its profits to the Government in taxes. This automatically pushed up the price at which industry could afford to sell its goods, and such taxation was an important factor in high prices. Thus, Sir Edward said, industry and commerce welcomed the Chancellor's assurance that the Government had every intention of cutting down its own expenditure ; that could be a decisive factor in holding inflation.

Employment and Unemployment

The Ministry of Labour's report on the employment situation in Great Britain in March shows that the total working population at the end of the month was 23,950,000, which was 35,000 less than at the end of February. The number in civil employment at the end of March was 22,950,000, which was virtually the same as a month earlier. A decrease during March of 35,000 in the total number employed in the manufacturing industries was offset by increases in building and contracting and in the basic industries.

The Ministry's analysis of the civil employment figures for March indicates that there were 3,965,000 people at work in the basic industries. Seasonal increases in transport and agriculture were reported, and there was also an addition of 1000 to the coal mining labour force which, at the end of March, numbered 705,000. The number employed in the manufacturing industries at the end of March was 9,298,000. Most of the manufacturing groups reported decreases, the most noticeable being in the engineering, metal goods and precision instruments group, the labour force of which declined by 13,000 to 2,810,000. In the vehicle building industry, the number employed was 1,254,000, which was 4000 less than at the end of February.

The unemployment figures given in the Ministry's report show the position on April 16th, when 251,515 were registered as out of work. On March 12th, the number of unemployed was 265,522. The Ministry says that the April unemployment figure represents 1·2 per cent of the total number of employees. It included 23,987 who were described as temporarily stopped.

Productivity in Freight Handling

The British Productivity Council has published a report entitled *Productivity in Freight Handling*. It is stated to be a record of recent progress on the railways and roads and at the docks.

The report emphasises that no other section of industry plays such a significant part in our national economy as that responsible for handling and moving the goods we produce. Transport, it is pointed out, is by far Britain's largest industry, employing about 9 per cent of the total working population, its cost to the country being in the region of £1800 million a year. Investment in British transport, the report says, is well over £3000 million.

The report surveys freight services on the railways and roads and at the docks. It comments that freight handling and the factors affecting it, while generally recognised as being of great importance, have not attracted " so positive a drive towards improvement as has characterised many producing industries." The report makes reference to progress which has been made in recent years, particularly in mechanical handling and in the adaptation of buildings to deal with new forms of handling. It says also that " some traders have equipped themselves to use whatever form of transport their circumstances dictate, but while they are placed in a comparatively happy position, their example is not capable of being followed widely owing to the heavy capital expenditure involved." The indications are that in a few years' time, the report adds, " there will be a need for much closer integration between the various forms of freight transport in this country and for the development of standard equipment which will be interchangeable between the various forms of transport, particularly road and rail."

Automation

Last Tuesday, the Minister of Labour, Mr. Iain Macleod, said in the House of Commons that he proposed to discuss the problems of automation with the National Joint Advisory Council, on which employers, trades unions and the nationalised industries are represented. The forthcoming report on automation by the Department of Scientific and Industrial Research, the Minister explained, would serve as a basis for the talks.

Mr. Macleod commented that, for many years, technological development had been a feature of our economic life, and that automation was " its latest and most novel form." It was welcomed by the Government and responsible opinion on both sides of industry as essential to our future efficiency and, therefore, to the continuance of full employment. The Minister went on to say that there were bound to be employment problems involving the redeployment of labour, and new skills would certainly be required. Those problems could be satisfactorily resolved if the Government and both sides of industry worked in close co-operation with each other. It was essential, Mr. Macleod added, that firms contemplating the introduction of automation should in their planning consider from the beginning how it would affect their workers, and bring them into early discussion.

German Industries Fair, Hanover

No. I

THE tenth German Industries Fair, which opened at Hanover on Sunday, April 29th, and closed on Tuesday, May 8th, again combined the light and heavy sections of the Fair. As may be seen from the accompanying table, this year the Fair was larger than ever

Development of Hanover Fair

Year	Halls, square metres	Open area, square metres
1947	30,000	8,000
1948	55,000	11,000
1949	149,000	16,000
1950	75,000	30,000
1951	144,000	40,000
1952	150,000	45,000
1953	150,000	55,000
1954	205,000	55,000
1955	220,000	75,000
1956	230,000	120,000

before, and the number of visitors and foreign delegations was increased.

On Saturday evening, April 28th, an informal dinner took place at which exhibitors and Press representatives were welcomed on behalf of the Deutsche Messe-und Austellungs-A.G. by the chairman of the board of directors, Minister Alfred Kubel. In the course of the evening, Mr. Otto Wolf von Amerongen gave an address in which he described the work of the German delegation which recently, by way of Great Britain and America, visited Japan, Hong Kong, Singapore, Thailand, Burma, India, and Pakistan. He dealt fully with the prospects of trade with these countries.

On Sunday morning, April 29th, a festive opening ceremony took place to mark the tenth anniversary of the Fair. The proceedings began with a rendering of part of Robert Schumann's "Spring Symphony," by the Niedersächsisches Symphony Orchestra, under its conductor Dr. Helmuth Thierfelder. Minister Alfred Kubel then welcomed all in the name of the Deutsche Messe-und Austellungs-A.G. He reviewed the growth of the Fair during the last ten years and expressed the hope that this year's Fair would further extend its reputation as an international market.

Dr. N. A. Mence, vice-president of the Association of German Industry, and president of the Chemical Industry Section, then spoke on behalf of German industry and referred to the Fair as a barometer of market fluctuations. Industrial progress was, he said, endangered by rises in the cost of production, and he suggested that a further use of automatic controls for various processes would result in lowering costs of production. It must not be forgotten, however, that such automatic controls would demand higher qualifications from the workers. He then described the efforts now being made to increase German supplies of coal, oil and electrical and atomic energy. Export trade, he went on to say, was necessary for national existence, and now the Fair had established itself as a meeting place for buyers from all parts of the world, its future was assured. Professor Dr. Ludwig Erhard, Minister of National Economy, then officially declared the Fair open. The ceremony closed with a rendering of festive music from Edward Grieg's "Sigurd Jorsalfar,"

As already mentioned, this year the size of the exhibition spaces was again enlarged. The total covered space in the halls was 230,000 square metres, and the open-air exhibition space 120,000 square metres. These figures compare with 30,000 and 8000 square metres respectively in 1947.

In Fig. 1 we reproduce an aerial view of the open-air space, which has been increased from last year's 75,000 square metres. Hall space has been increased principally by the addition of a steel-framed structure of 8900 square metres, Hall 8*a*, between Halls 8 and 9.

The New Demag Building

The new building constructed on the Demag Aktiengesellschaft site by the firm's structural department and the firm of Rüter is an attractive two-storey building, exemplifying the modern use of steel and glass in structural work. On the ground floor we noted some fine models of iron and steel works and rolling mills constructed by the firm. These were supplemented by model exhibits on the top floor of heavy machinery, cranes and other handling and loading machinery.

In the front of the building, as will be seen from Fig. 2, there is ample space for exhibits, and two examples were shown of the recently introduced hydraulically controlled excavator, which was described in our "Continental Engineering News" on December 2, 1955, page 813. In front of the building the company also showed for the first time parts of a rotary deep-well drilling jig, which later will be put into use in an oilfield near Hanover. The new building also provides offices and reception rooms and, in addition, there is a conference room which can also be used as a cinema to show films to about 100 persons.

The Hermes Observation Tower

In the centre of the open-air exhibition space there has been built (as shown in Fig. 1) a new observation tower. This is more clearly shown in Fig. 3. The tower consists of two elliptically spaced pillars which are joined at intervals by bracing members. The whole structure is of reinforced concrete except that prestressed steel is used in the foundation members. The observation platform is at a height of 75m and the top spire is capped by the Fair sign, the head of Hermes, from which the tower takes its name. The height to the top of the spire is about 73m. The observation platform for 100 persons, which is situated at a height of 65m, is constructed in the form of a star, and above it is a cafe with accommodation for forty-five guests. On the roof of the cafe are parallel aerials for telephones and wireless transmission. The calculations and design were executed by Dr.-Ing. Fritz Leonhardt of Stuttgart, and the architectural features were designed by Dipl.-Ing. Werner Gabriel, also of Stuttgart. The tower was built by two firms, Hans and Lenze, of Geseke (Westphalia), and Ludwig Bauer, of Stuttgart, together with the Cement Union of Cologne, the firms forming a company to undertake and finance the building and equipment of the tower. The lift was designed and supplied by R. Stahl, of Stuttgart, and the electrical machinery and electrical controls by

Fig. 1—Aerial view of open air section with "Hermes Tower"

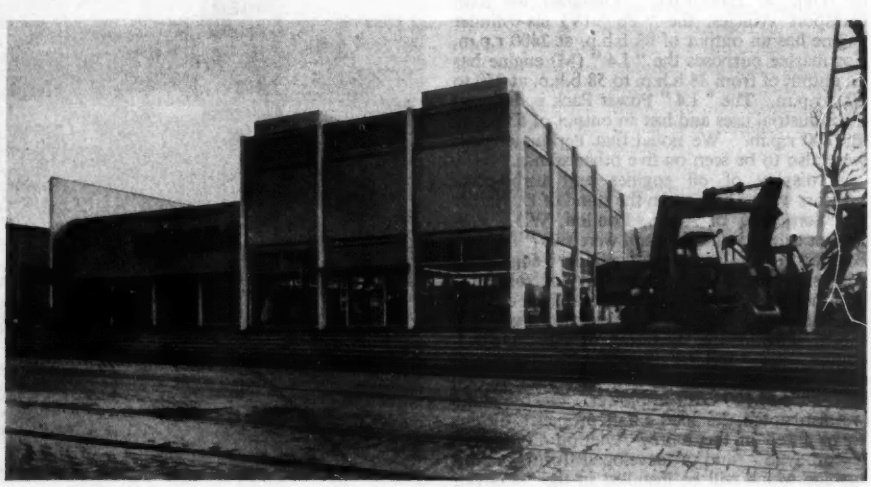


Fig. 2—New Demag buildings

the A.E.G. Company. The lift, which runs on rails attached to the two pillars, is designed to accommodate fourteen persons, and the ascent to the observation platform is made in about fifteen seconds at a speed which reaches a maximum of 6m per second. The driving motor is a d.c. machine with Ward-Leonard equipment, and has an output of 52 h.p. at 105 r.p.m. The latest A.E.G. " Eldro " braking system is fitted with electronic control gear.

Before passing to descriptions of machinery shown at the Fair we would make special reference to three British exhibits.

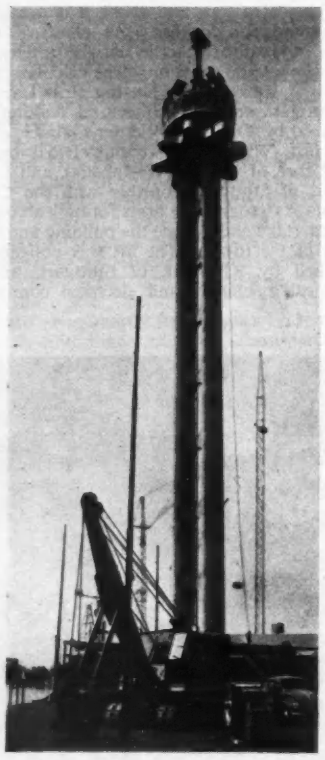


Fig. 3—View of "Hermes" observation tower

Some British Exhibits

Among the oil engines seen in Hall 3, Perkins Limited, of Peterborough, showed a fine range of engines designed for various uses. Engines for tractors were represented by the " P3 " (T.A.), built for tractor applications ; a three-cylinder unit having an output of 32 b.h.p. and running at 2000 r.p.m.; and the " L4 " (T.A.) engine, a four-cylinder unit developing 62 b.h.p. at 2000 r.p.m. Designed for road transport vehicles, the " P6 " (V) six-cylinder engine has an output of 83 b.h.p. at 2400 r.p.m. For marine purposes the " L4 " (M) engine has an output of from 38 b.h.p. to 58 b.h.p. at 250 to 2000 r.p.m. The " L4 " Power Pack is designed for industrial uses and has an output of 53 b.h.p. at 1800 r.p.m. We noted that Perkins engines were also to be seen on five other stands.

A display of oil engines and turbo-compressors was to be seen on the stand of D. Napier and Son, Ltd., of Acton, London, W.3. Prominent exhibits on this stand were two " Deltic " engines, one an eighteen-cylinder engine of 2500 s.h.p. as fitted in Royal Navy patrol boats, and the other a nine-cylinder, 860 b.h.p. unit for driving a generator. There was also a working model showing the operation of the " Deltic " engine. An " MS. 600 " turbo-blower was also on view, as well as shaft assemblies and a section of the " MS.100 " turbo-blower. On the stand we also noted the 3000 e.h.p. propeller turbine to be fitted in the Fairey Aviation Company's " Rotodyne " and a developed form of this turbine which will be installed in the " Convair 340 " air liner and the British European Airways " Elizabethan " aircraft. In addition there was also shown the " Gazelle " engine, which is a free turbine of 1280 s.h.p. This unit will be fitted in the " Bristol 192 " twin-rotor helicopter and the Westland " Wessex " helicopter. Another engine shown on the stand was the " Oryx " gas generator of 750 g.h.p., which has already been type-tested at 750 g.h.p. and is to be installed in the Hunting Percival " P.74 " helicopters. The Napier Company also showed a range of applications for its " Spraymat " system of electrical surface heating, which is now in use with many military and commercial aircraft, and also has many uses for the de-icing of ships operating in very cold climates.

Among the open-air exhibits we saw on the stand of Natorp, of Mülheim (Ruhr), a group of exhibits by David Brown, Ltd., of Huddersfield. They included examples of the " Merton " overloader, angledozers and bulldozers.

(To be continued)

Hydraulic Planing Machines

Our illustration shows what is claimed to be the largest hydraulic planing machine built to date, which was recently completed at the works of Adolf Waldrich-Coburg K.G., Coburg (Bavaria). It is a double-housing planer for workpieces up to 3250mm wide and 3500mm high. The table is 3000mm wide and the maximum stroke is 8000 mm. With a length of the bed of 19m, the weight of the machine is 180 tons. The table movement is obtained by means of a double cylinder arrangement, supplied by a variable delivery oil pump which is driven by the 100kW main motor. Maximum cutting force is 14,000 kg, and table speeds between 6m and 50m per minute can be selected.

Two tool supports are mounted on the cross-rail and one on each of the housings. They can be moved independently of one another.

Each support can be swivelled, and has an automatic horizontal and vertical feed. The amount of feed is set on a control panel situated by the side of the machine, while the feed clutch is let in from the control panel suspended from a swivel arm. This panel contains all the push-buttons for obtaining the rapid traverses of the supports, the table and the cross-rail and the selector switches for " setting up " and " operation," as well as for locking the cross-rail.

A platform is fitted to the cross-rail to facilitate setting the tools and operating the machine. It comprises two sliding portions which can be moved horizontally to meet in the middle.

Supports, gearboxes and cross-rail are all centrally lubricated. For the bed, pressure lubrication has been provided which can be adjusted independently for each of the guide ways. In this manner the oil pressure can be adapted to the existing load on the table, and eccentric loading can be allowed for. The whole construction is particularly rigid. Accuracy is stated to be very high and to exceed the Schlesinger standards.

Agent for the United Kingdom is Drummond-Asquith (Sales), Ltd., King Edward House, New Street, Birmingham, 2.

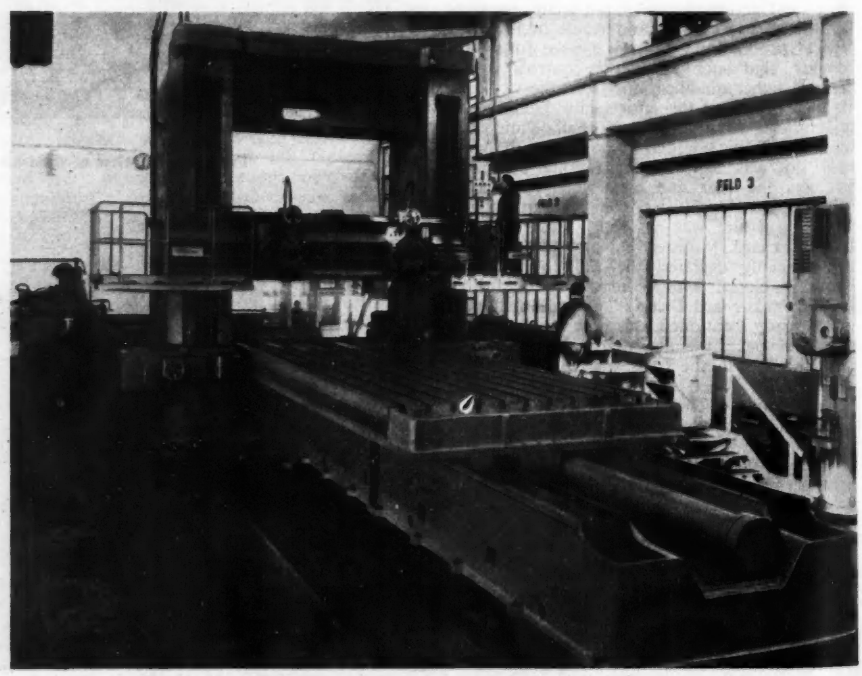
V.D.I. Committee on Refuse Disposal

The unsatisfactory technical state of the problem of domestic refuse disposal has led the V.D.I. Domestic Technology Group to form a committee on Refuse Disposal, jointly with the Association of Communal Transport Fleet Operators, Frankfurt on Main. It was said at the inaugural meeting on January 25th that in some instances over 50 per cent of the cost of refuse removal could be saved by improving the design of dustbins and their location in or near dwellings. The work of refuse collection could be made more systematic, and at the same time could be rendered less heavy and existing dangers to the workmen lessened. Reference was made to experience in Sweden, Switzerland and in the U.S.A. It will be the task of the committee to work for the best use of existing equipment and its full and systematic application, to study new means of refuse disposal, to develop design principles for equipment, and to bring out information leaflets for architects, landlords and local building authorities.

Iron Ore Production in Sweden

Production of iron ore in Sweden amounted to 17·45 million tons during 1955, as compared with 15·33 million tons and 16·98 million tons in 1954 and 1953, respectively. Exports, at 15·65 million tons, fell short by only 10,000 tons of the 1952 record, but exceeded the 1954 shipments by 1·57 million tons.

The rise in exports last year was primarily due to shipments to the German Federal Republic which advanced from 4·8 million tons in 1954 to about 6·5 million tons last year. Exports to the United States of America gradually decreased from 2·1 million tons in 1953, to 1·6 million tons in 1954, and 1·1 million tons in 1955. A further decrease to under 1,000,000 tons is anticipated for this year, while exports to the Federal Republic are stated to be likely to exceed 7,000,000 tons.



Double-housing planing machine, for workpieces up to 3250mm wide by 3000mm high. The bed is 19m long, the maximum stroke is 8m

Swiss Public Works Plan, 1956 to 1960

The survey made last year of the Swiss public works programme for the years 1956 to 1960 shows that the Swiss authorities have projects in hand totalling 10,500 million francs. Of these, about three-quarters are civil engineering projects and the remainder buildings. The most important among the civil engineering schemes are dykes, river works, and canals, which together account for 36·6 per cent of the proposed expenditure. About 21·5 per cent concern road improvements, and 14·2 per cent land improvements and other civil engineering works.

Of the constructional works, some 8·5 per cent of the total is earmarked for schools, while 5·4 per cent is for hospitals and institutions, 2·1 per cent for office buildings, and 11·7 per cent for churches and other public buildings.

Rather over one-fifth, viz. 2200 million francs, relates to schemes which are ready to be carried out and for which money has been made available. Another 18 per cent of projects have had complete plans drawn up, but no money has so far been allocated. Yet another 39·5 per cent of projects are being studied, and a further 21·4 per cent are at a preliminary stage of survey. Table I illustrates expenditure under the various heads, while Table II shows an analysis according to the authorities concerned.

Compared with the previous survey, made in 1952, the present one shows a decrease in governmental activity in the civil engineering and constructional fields, and some decrease in the activities of private railways. On the other hand, the remainder of the programme shows considerable increases over 1952. Most of these were noted in connection with work to be carried out by the cantons, and in connection with privately-owned electric power stations (index figures 139 and 141 respectively, if 1952=100).

The total of fully planned projects has risen 29 per cent over 1952, for projects the plans for which are not yet complete, the figure is 28 per cent.

TABLE I.—*Swiss Public Works Programme* 1956-60 (*in millions of francs*)

Category	Project ready		Project not ready		Total	Percentage
	Financed	Not yet financed	Under study	Not under study		
Civil engineering :						
Roads	326·5	442·5	749·4	730·5	2248·9	21·5
Dykes, river regulations, canals	984·9	677·7	1740·2	426·2	3829·0	36·6
Land improvement	42·7	35·2	51·7	108·3	237·9	2·3
Other works	248·2	260·7	505·2	230·4	1244·5	11·9
Total	1602·3	1416·1	3046·5	1495·4	7560·3	72·3
Constructional work :						
Offices	38·5	23·0	65·6	94·0	221·1	2·1
Schools, gymnasiums	167·1	175·2	246·2	304·9	893·4	8·5
Churches	23·6	16·9	45·2	29·0	114·7	1·1
Hospitals, institutions	168·0	42·3	232·8	116·4	559·5	5·4
Other works	201·2	208·4	490·9	202·5	1103·0	10·6
Total	598·4	465·8	1080·7	746·8	2891·7	27·7
Together	2200·7 = 21·1 per cent	1881·9 = 18·0 per cent	4127·2 = 39·5 per cent	2242·2 = 21·4 per cent	10,452·0 = 100 per cent	100·0

TABLE II—*Swiss Public Works Plan*, 1956–60 (*in millions of francs*)

Category	Project ready		Project not ready		Total	Percentage
	Financed	Not yet financed	Under study	Not under study		
Federal office of works	16·4	35·2	8·7	10·1	70·4	0·7
C.F.F.	229·2	218·0	366·3	143·7	957·2	9·2
P.T.T.	15·1	12·0	0·01	52·6	79·6	0·8
Other federal agencies	94·8	27·0	—	—	121·9	1·1
Confederation	355·5	292·2	375·0	206·4	1229·1	11·8
Cantons	570·7	502·5	1109·7	860·6	3043·5	29·1
Municipalities	598·5	555·8	1114·8	1070·3	3339·5	32·0
Private railways	10·1	9·0	28·1	6·2	53·4	0·5
Private power stations	665·8	522·4	1499·4	98·6	2786·3	26·6
Total	2200·6	1881·9	4127·0	2242·1	10,451·8	100·0

Atomic Progress in Switzerland

On March 1, 1955, the Société Réacteur S.A. was founded by Brown Boveri et Cie, Escher Wyss, and Sulzer Bros. In April it was decided that the firms of Electro-Watt and Motor-Columbus should join forces for the construction of an experimental reactor using heavy water, the "P34"; following the atomic conference at Geneva, it was decided to increase the capacity of this reactor by one-quarter, and in addition to purchase the reactor which the United States had shown at Geneva. These two reactors will be used for the training of specialists and for scientific research.

Société Réacteur employs twenty-seven scientists and engineers, of whom ten have been seconded from the three parent companies. It is intended to engage, in the course of the year, two or three physicists, two or three engineers, two chemists and two metallurgists, so that the seconded personnel can be withdrawn. The company is financed by 125 shareholding firms of which 49 per cent are industrial enterprises, 31 per cent in the electrical field, and 20 per cent are banks, insurance companies and finance corporations. On March 25th last year, an agreement was concluded with the Swiss Government, concerning the construction and operation of an atomic reactor. The Confederation is to support the company to the extent of 5,000,000 francs, and to subscribe the operating costs of the reactor by paying a maximum of 1,800,000 francs before completion and up to 5,000,000 francs thereafter, in annual instalments of 1,000,000 francs. The share capital of Réacteur S.A. has been raised to 1,625,000 francs, and the shareholders have undertaken to pay an additional 14,600,000 francs *à fonds perdu* during the next ten years.

Swedish Engineering in 1955

According to the annual report of the Federation of Swedish Mechanical Engineering Industries, the number of man-hours worked in the Swedish engineering industry increased last year by 4 to 5 per cent. The number of workers increased by about 11,000, but in spite of this there has been a shortage of man-power.

Exports of engineering products last year amounted to Kr.2455 million compared with Kr.2341 million in 1954. Details are shown in the accompanying table.

TABLE—*Swedish Exports of Engineering Products*

(Kr. million)

	1955	1954
Iron and steel	440	387
Machines (including electrical equipment	1021	990
Vehicles	190	148
Ships	564	600
Instruments, office machines	144	127
Army ammunition	96	89
Total	2455	2341

It will be noted that all exports with the exception of ships have shown increases. Some price increases have occurred in connection with machine tools which, it is said, have had an unfavourable effect on exports. The order books of the major shipbuilding yards are stated to be full for two to three years ahead. Foundries have been working to capacity. A certain decline in home sales of agricultural machinery is attributed to last year's poor crops and the tightening-up of credit restrictions.

Servo-Testing Equipment

Among the exhibits at the recent Milan Fair (April 12th to 27th), a range of servo-test equipment was shown by Solartron Electronic Group, Ltd., Thames Ditton, Surrey. Servo-systems, which are the backbone of all automatic control installations, are now so widely used in large numbers, e.g. in guided weapons, aircraft auto-pilots, and industrial proceses, that a quick and efficient method of testing had to be devised. In fact, servo-systems must now be mass produced, which means it must be possible to test them on a like scale; moreover, new servo-systems must be tested thoroughly, accurately and quickly.

The equipment shown at Milan consisted of a transfer function analyser, a feed-back voltmeter, and a servo-test set. In addition, other apparatus was shown including a wide range oscillator, square wave generator, and a synchro voltmeter.

The transfer function analyser is an instrument for testing servo-mechanism under conditions where the servo-output may be non-linear. It is stated to be able to measure the efficiency of almost every kind of servo-mechanism manufactured, and while detecting imperfections, discriminates against harmonic, spurious and unwanted frequencies. It has two dials for obtaining the necessary information for plotting Nyquist diagrams. A range of 0·1 kc/sec to 1 kc/sec enables it to be used in testing such equipment as the high-speed servos, which are becoming prominent in aircraft and guided missiles. All necessary information is shown on two meter dials for the accurate plotting of Nyquist diagrams.

The feedback voltmeter is an extremely accurate valve voltmeter (accurate to ± 1 per cent), and has a range of from 0·00002V to 150V. No measurable change in the meter reading is observed when there is a change in the main supply current of ± 10 per cent.

The servo-test set is designed to save time spent in testing, and allows the equipment to be tested at four spot frequencies on the "yes" or "no" principle.

Swedish Welded Tube Mill

The first plant in Scandinavia for the production of large welded tubes recently began operation in Stockholm. Owned by AB. Bröderna Hedlund, the plant forms an extension of the company's workshops at Hammarby harbour. It has an area of about 5000 square metres. The equipment is largely of German design, and enables steel tubes to be manufactured from 300mm diameter upwards, in lengths of 8m. Plates up to 15mm thick are used, which after being cut, rolled, and shaped, are welded inside and outside by machine. After straightening, the completed tubes are tested with X-rays and water pressure. In some instances tubes are assembled by welding into 16m lengths. There is a keen demand in Sweden for this kind of tube for water, steam, gas and other purposes. A.B. Bröderna Hedlund, structural engineers and contractors, who previously made welded tubes of shorter length, are also envisaging the export of tubes, in the first instance to other Scandinavian countries.

Road Accidents in Switzerland

According to statistics referring to 1955, the total number of traffic accidents in Switzerland amounted to 45,800, involving injury to 28,100 people as well as 1019 deaths. This compares with a total of 43,500 accidents involving 26,730 cases of injury and 963 deaths, in the year 1954. Although these figures constitute increases of 5 per cent in the number of accidents and of people injured, and 6 per cent in the number of people killed, the number of cars in Switzerland during last year increased at a much greater rate, by 12 per cent, while the numbers of foreign cars and motor cycles increased by 18 per cent. These figures are claimed to show that road safety measures have met with a certain amount of success.

Failure of 150MW Turbo-Generator Low-Pressure Turbine Spindle

BY OUR AMERICAN EDITOR

At the Ridgeland power station of the Commonwealth Edison Company, near Chicago, Illinois, on December 19, 1954, the low-pressure turbine spindle of a 150MW cross-compound steam turbo-generator burst during a routine over-speed trip test. Immediately following this accident an intensive investigation of the design, metallurgy and manufacture of the spindle and of the operational history of the turbine was initiated and its results have now been released by the Allis-Chalmers Manufacturing Company, the builders of the turbo-generator. It is believed that the accident was caused by hydrogen flakes or thermal cracks developed in the shaft during heat-treatment.

As reported originally in our issue of February 25, 1955, one of the worst accidents to occur in the American electrical industry during 1954 was an explosion in the low-pressure turbine of a new 150MW cross-compound, steam turbo-generator at the Ridgeland power station of the Commonwealth Edison Company, at Stickney, Illinois. The explosion occurred on Sunday, December 19th, at 11.19 p.m., as the unit was being brought into service. The blast destroyed the turbine, and flying metal and debris caused considerable damage to the station building and adjacent units. Two men were killed and five others injured in the accident that threw the station out of operation. The station's 600MW total capacity represents some 18 per cent of the Commonwealth Edison generating capacity of 3422MW, and its loss made it necessary for the company to ask 100 of its largest customers to cut load by 25 per cent. The unit involved in the blast was the latest of four similar units at Ridgeland, having been placed in service in August, 1954.

Turbine Design

The so-called Ridgeland No. 4 turbo-generator is of conventional American cross-compound design, with the high-pressure turbine turning at 3600 r.p.m. and the intermediate-pressure and low-pressure turbines in tandem on the 1800 r.p.m. shaft. The unit is rated at 150/165MW and was placed in commercial service on August 19, 1954. The 1800 r.p.m. low-pressure turbine is of double-flow construction. One end of the shaft is solidly coupled to the low-pressure end of the intermediate-pressure turbine spindle, and the other end is solidly coupled to the generator rotor. The cylinder is of conventional cast iron construction, with two cross-over pipes connected at the top. Fig. 1 shows the general construction and principal dimensions of the low-pressure turbine spindle. The high-pressure blades are carried in grooves machined directly into the main spindle shaft body. The last three rows of blades in each flow are mounted in heavy rings shrunk on to the spindle shaft extensions. There is a circumferential groove at the centre of the main body with an integral central ring for balance plug holes. A central bore extends through the complete length of the shaft.

Five turbines, including the Ridgeland unit, have been built and placed into operation by the Allis-Chalmers Manufacturing Company with low-pressure spindles of essentially identical construction. During the preliminary design phase on the first of these units two designs of spindle constructions were laid out. The first design contemplated the use of a central shaft with all blading carried on shrunk-on rings. Critical speed considerations dictated the use of a large shaft diameter under all rings, resulting in ring stresses too high for the material with which the builders had the most experience at that time. The second design, which was the one finally selected, utilised a shaft with a large-diameter central body to carry the high-pressure blading and small-diameter extensions with shrunk-on rings for the last three stages of each flow. This design permitted low stress levels in the rings without undue increase in shaft flexibility. The stress analysis performed in the design of a highly loaded structure such as a turbine shaft includes the calculation of centrifugal, torsional and bending stresses at many local points under varying conditions of operation. However, the basic criterion for acceptability is the average tangential stress. This criterion has been used for many years by most large turbine designers, and it has since been adopted by both the U.S. Navy and the American Bureau of Shipping.

The average tangential stress is the stress imposed on the radial cross-sectional area of the spindle by the centrifugal load of the blades and the spindle mass of the section. Burst tests of discs and small shafts have shown that the average tangential stress is an accurate measure of the actual bursting speed, and bursting speeds have been found to be relatively independent of any localised high stresses, provided there is a moderate amount of ductility in the material. The maximum value of the calculated average tangential stress in the Ridgeland low-pressure spindle shaft is 19,660 lb per square inch at 1800 r.p.m. and exists in the portion of the main body toward the intermediate-pressure turbine end. The factors of safety on these stresses as required by the makers are identical with those of the American Bureau of Shipping and are common with those of most large turbine builders. At normal speed the minimum factor of safety must be not less than four on ultimate strength and not less than three on yield strength. These factors of safety have been in use for many years, and their purpose is to cover overspeed requirements, normal variations in material properties, minor flaws and discontinuities, normal variations in quality of workmanship, and approximations in stress analysis. To meet the requirements of the calculated stresses and the specified factors of safety the spindle shaft was made from a nickel-molybdenum-vanadium steel forging, ordered to Allis-Chalmers Material Specification ACM-11. This material is in general accordance with ASTM Specification A293, Class 6 (" Carbon and Alloy Steel Forgings for Turbine Rotors and Shafts "). The specified chemical analysis and physical properties were as follows :—

	per cent		per cent
Chemical Analysis :			
Carbon	0·25	to	0·35
Nickel	2·50	to	3·50
Chromium	0·25	to	0·75
Molybdenum	0·40	to	0·60
Vanadium	0·05 minimum		
Physical Properties :			
Tensile strength	105,000 lb per square inch.		
Yield strength (0·02 per cent)	85,000 lb per square inch.		
Elongation (in 2in):			
Longitudinal	16 per cent		
Transverse or radial	12 per cent		
Reduction of area:			
Longitudinal	30 per cent		
Transverse or radial	23 per cent		

The specification required that the ingot be reduced by forging in the ratio of 1·4 to 1 prior to upsetting. After forging, the ingot was to be given a flake or thermal crack protection cycle. Physical properties were to be obtained by normalising and tempering after rough machining. The last heat-treating temperature was to be not less than 1150 deg. Fah. Under " Inspection and Tests " the specification included heat indication, dimensional inspection, and visual inspection of the bore. It was required that under careful inspection the forging should not exhibit injurious defects such as seams, flake holes or flaws of any kind either on the outside or in the bore. Ultrasonic inspection was also specified, but by agreement with the forging manufacturer his test was to be for information purposes only and was not to be used as a basis for acceptance or rejection of the forging. This was normal procedure at the time the forging was ordered (1951), in view of the general lack of experience with the method at that time.

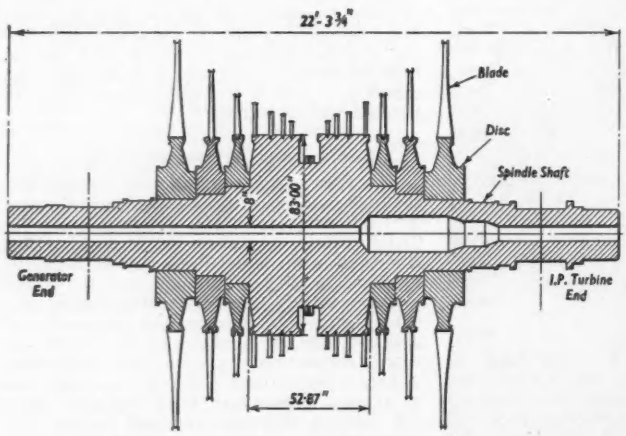


Fig. 1—General arrangement of low-pressure turbine rotor

Fig. 2—Ridgeland power station turbine room after the accident

Manufacture of Spindle Shaft

The low-pressure spindle-shaft forging for the Ridgeland unit was supplied by the forging manufacturer in a fully heat-treated and rough-machined condition. The forging was made from a 108in ingot weighing 372,000 lb. Blocking, upsetting and reblocking were done on a 7500-ton press, with a total reduction of 3·25 to 1. The forging was then given a 470-hour conditioning cycle followed by rough machining for preliminary inspection. In the preliminary inspection the centre bore was inspected optically and the main body was tested by sonic means both before and after boring. Sulphur prints were taken on the faces of the main body, and the fillets joining the main body and shaft ends were tested by the magnetic-particle method. Following preliminary inspection, the rough-machined forging was heat-treated to obtain the desired physical properties. This heat-treatment required 380 hours and consisted of double-normalising at 1640 deg. Fah. and 1600 deg. Fah. and tempering at 1180 deg. Fah., followed by slow cooling. Four test bars were then taken and the tests witnessed and certified by Allis-Chalmers inspectors. The minimum properties from the bars met the specifications and were reported as follows :

Tensile strength	111,000 lb per square inch.
Yield strength	85,000 lb per square inch.
Elongation	19·0 per cent.
Reduction of area	50·8 per cent.

Following heat-treatment, the forging was given a final rough machining and annealing, and final optical "borescope" and sonic tests were completed. In the borescope inspection, discontinuities were observed in one of the shaft extensions adjacent to the main body. The original 8in bore at this point was increased in several successive steps to slightly over 16in, at which diameter the bore was found to be free from visual defects. The forging manufacturer's sonic tests disclosed a general area within the main body in which sonic indications were found, varying from very small to somewhat over 100 per cent of the back reflection. In view of the satisfactory visual bore condition, it was decided to continue the processing of the forging. Following sonic tests, the rough-machined forging was heat indicated for stability, the shaft being rotated slowly for about eleven hours at 1100 deg. Fah. and twenty hours at 950 deg. Fah. The shaft was found to be very stable. A second final sonic test of the forging was performed in the manufacturer's works by Allis-Chalmers inspectors. This test confirmed those previously performed by the forging manufacturer. In view of the nature of the defects observed during visual inspection of the bore, it was considered by all concerned that the sonic indications in the main body were inclusions and stringers of a harmless nature.

Operating History

The Ridgeland No. 4 turbo-generator was first brought up to speed on July 17, 1954. Five over-speed runs were made on that date during various operational checks. The unit was placed in regular scheduled service on August 19th, and there were a total of ten start-up's, including nine over-speed tests, prior to the start-up of December 19th. The vibration history of the turbine during this period was excellent. Operation was smoother than average in the opinion of both the field engineers of the makers and the station operators.

The unit was taken off the line in the evening of December 17th to clean the boiler. Both shafts were kept on turning gear until the evening of December 19th, at which time the turbine was rolled with steam preparatory to being put back on the line. The speed was brought up to 3000 r.p.m., as measured on the high-speed shaft, in about an hour and a half, and the vacuum-trip setting was checked. Following this trip, the speed dropped to about 1500 r.p.m. The high-pressure shaft governor was then made inoperative and speed was increased until the low-pressure shaft over-speed governor tripped the unit at 7·8 per cent over-speed. The speed dropped to about 3000 r.p.m., at which point the trip tester was placed in position to make the low-pressure over-speed trip inoperative during the anticipated succeeding high-pressure turbine trip. Speed was then again increased and at 3910 r.p.m. or 1955 r.p.m. on the low-speed shaft, corresponding to 8·6 per cent over-speed, the low-pressure turbine spindle exploded. The accident occurred without warning, there being no noise or rubs or other abnormal indications up to the instant of failure. Fig. 2 is a photograph of the interior of the power station taken shortly after the accident, showing the condition of the low-pressure turbine and the general damage to the station. Units 1, 2 and 3 were tripped immediately following the accident, as a result of damage caused by flying parts. Fig. 3 is a close-up photograph of the low-pressure turbine taken shortly after the accident. It will be noted that the main body of the spindle is completely gone, with the shaft extensions and shrunk-on discs remaining overhung due to the solid couplings to the intermediate-pressure turbine shaft and the generator rotor. The cross-over pipes and low-pressure turbine casing and cylinder rings were damaged beyond repair. There was miscellaneous damage to both the rotating and stationary elements of the intermediate-pressure turbine and generator, but not to such an extent that complete replacement of major parts has been required. Damage to the high-pressure turbine and generator was inconsequential.

Fig. 3—Photograph of the low-pressure turbine taken shortly after the accident

Initial Investigations

Although it was not possible to remove parts and fragments of the turbine from the station for some weeks following the accident, visual surveys of the spindle pieces were made immediately by the engineering and metallurgical staffs of the turbine builders. It was found that the main body had burst into four main pieces. One piece was hurled through the air and fell into the basement adjacent to the condenser of unit 1. Another piece flew in the opposite direction and was eventually found in the station coal pile. The remaining two pieces came to rest in the condenser of unit 4. It was noted that all these four fragments were almost true 90 deg. segments. A preliminary assembly of the spindle fragments at Ridgeland is shown in Fig. 4. The four quadrants of the main body are in the foreground. Some conical pieces mating with the quadrants were found as large separate pieces, but others were either shattered into a number of smaller fragments or remained with the shaft extensions. Of particular interest was a fatigue crack some 3in deep and 17in long in the fillet joining the shaft extension and main body at the generator end.

A preliminary estimate of the various factors which could have caused the accident was made during this initial period. From the pattern of the main body burst, which was determined from detailed measurements of the four main quadrants, it was evident that the failure extended in a main plane from end to end and was symmetrical to either side of the centre of the main body. This failure pattern is typical of a simple over-speed burst, although there was positive evidence that the actual speed of the spindle at the time of failure was far below the estimated bursting speed. It was then conjectured that the same burst pattern could have resulted at a much lower speed if there were flaws or poor material near the centre of the main body. In this case, the speed at which bursting would occur would depend largely upon the nature of the flaws or the extent of the inferior material. A considerable amount of attention was given to the possibility of the failure originating with the fatigue crack, which in turn could have resulted from stress concentrations in the fillet joining the main body and shaft extensions or in the combination of fillet and adjacent shrink under the rings. These possibilities could not be ruled out, although it was though at that time that the fatigue crack was not a major factor in the primary failure. It was considered that the crack had not progressed deep enough to cause complete destruction of the shaft, and in any case such a crack would be unlikely to cause a burst failure of the main body. In considering the effect of the adjacent shrink fit, it was noted that the fatigue crack originated high on the fillet, well away from the edge of the shrunk-on ring.

As soon as possible following the accident, a re-analysis was completed of the stresses in the low-pressure turbine spindle shaft. In reviewing the results of this stress analysis, it was concluded that, while there were some unknowns and the calculations could perhaps be refined to some degree, the general stress level was very conservative and the margins of safety were adequate, given sound material. Computed stresses are mainly relative, and those in the Ridgeland shaft were in general lower than stresses in current 3600 r.p.m. designs. It was considered that the unknown influences of size, material, and other variables were covered by adequate factors of safety when compared with available burst-test data.

A thorough investigation was made of the machining procedures and shop practices employed on the Ridgeland shaft, from initial receipt of materials to the final completion of installation. Examination of all pertinent records disclosed nothing of significance. Visual inspection of turbine parts revealed no obvious defects such as machining errors, tool marks, or other fabrication damage. It was found that inspection records were adequate and in accordance with established practice.

An examination of the operating records of unit 4, covering the period from the in-service date to immediately before the accident, revealed nothing abnormal. There was no difficulty of significance at any time in the operating history of the turbine. At the start-up on December 19th, the high-speed and low-speed generators were synchronised while the unit was still on turning gear. The generators remained synchronised through the

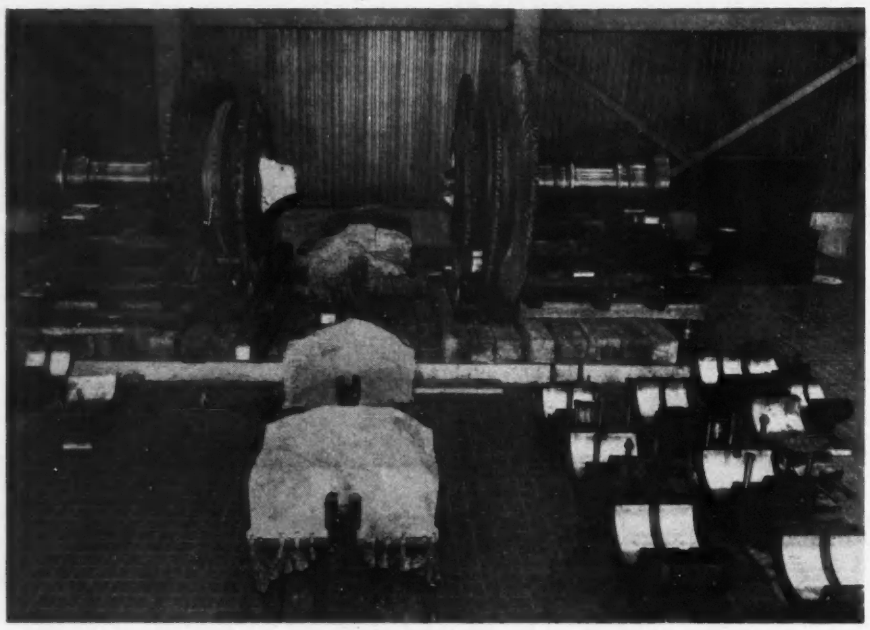


Fig. 4—Preliminary assembly of spindle fragments and other parts of the turbine

accident, and after the low-pressure turbine failure the drag of the low-speed generator brought the 3600 r.p.m. elements to a stop in less than one minute. The steam temperature at the low-pressure turbine inlet was at a normal 300 deg. Fah. at the time of failure. The condenser vacuum was about 27½in. The starting time conformed to normal operating procedure, and there were three independent checks of speed at all times until an instant or so before failure. During the preceding twenty-five minutes, the vibration at the low-pressure bearing pedestals did not exceed 0·0003in, which is considered very good for a unit of this size.

Metallurgical Investigations

As soon as all parts and fragments of the low-pressure turbine assembly were received at the works of the builders, a reconstruction of the spindle from the fragments was started. The reconstructed spindle was reviewed in detail at a general meeting with representatives of the Commonwealth Edison Company, and a plan of metallurgical investigation was established. This plan called for the following specific investigations : detailed examination of parts for failure lines, hatch marks, &c.; magnetic-particle tests, acid etch, and sulphur prints of various slabs ; photomicrographs ; chemical analysis at various points ; determination of residual hydrogen ; tensile and impact tests of bars from various points ; ultrasonic tests of large fragments ; and profilometer examination of the fatigue crack.

A detailed examination of the markings on the fracture surfaces of the four main-body quadrants established two basic facts : first, all main fractures progressed from the bore toward the outside, and secondly, the main body split first into two halves and then each half split into quadrants. The cradle re-assembly of the quadrants and fragments composing one of the primary main-body halves showed failure marks, in general, continuously across this entire surface, indicating that the complete half separated from the other half prior to breaking into smaller parts. A similar re-assembly of one of the quadrants with a quadrant from the opposite half showed that the failure marks across the surfaces are not continuous, indicating that splits in the smaller parts occurred prior to splits in the main segments. These deductions from examinations of the cradle re-assemblies were confirmed when all four main-body quadrants were assembled together. Fig. 5 is a view of one end of the re-assembled main body. It is apparent from this picture that quadrants I and II were joined when they separated from quadrants III and IV, and the separation of quadrant I and quadrant II followed later. The position of the fatigue crack is evident in Fig. 5, and it will be noted that it has no significant relation to the main planes of failure. In summary, the detailed examination of the fracture surfaces clearly indicated that the spindle failure originated in the main body, spreading out both radially and longitudinally from the general vicinity of the central bore.

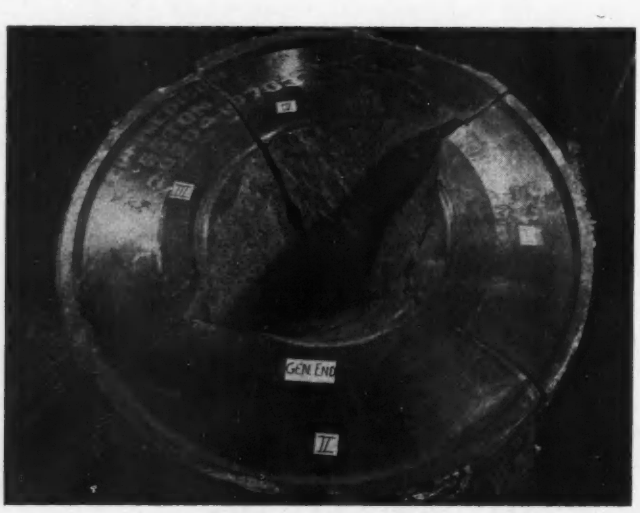


Fig. 5—Reassembled main body of rotor as seen from the generator end

The most significant phase of the metallurgical investigation was the macro-examination of various slabs cut from the main-body segments. The results of the magnetic-particle test of a longitudinal slab clearly indicated the presence of a large number of cracks in an area extending from near the bore out to approximately mid-radius. These cracks were several inches in length and longitudinal in direction. They followed a definite pattern in the forging and were concentrated in the main body. In the transverse plane the cracks were generally radial in direction, although some appeared at all angles. The average radial depth was of the order of 1in.

At this point in the investigation it became evident that the forging contained a typical flake or thermal crack pattern. This condition is characterised by cracks appearing in large numbers, fairly evenly distributed circumferentially from near the bore out to about mid-radius, and tending to lie in radial planes extending longitudinally. Magnetic particle tests of the fatigue crack area which caused concern throughout the investigation, showed the presence of numerous flakes in and around the fatigue crack, some lying at the fatigue crack initiating points, as determined from " beach marks " on the surfaces. Subsequently strain gauge tests by the Detroit Edison Company on a duplicate shaft and by the Battelle Memorial Institute on a 12in model shaft showed that the actual fillet stresses were conservative and slightly less than predicted by the designers. In the opinion of the builders it can only be concluded that the fatigue crack started from a flake and would not have appeared at all in the absence of this initiating crack.

Fig. 6 is a photomicrograph at 500× of a typical crack near the mid-radius of the forging. The extreme tightness of these cracks is well-demonstrated here. This is important in establishing the fact that the cracks were in the shaft prior to operation and were not secondary results of stresses imposed at the time of failure. This fact is corroborated by the absence of cracks near the bore, which is the most highly stressed area of the shaft.

The chemical analysis of material from various sections was well within the original specifications. The sulphur content was greater in the vicinity of the segregates or stringers, but it was not as high as expected, probably due to the difficulty of obtaining a true sample. Hydrogen checks made by the Battelle Memorial Institute showed the presence of only about 1 p.p.m. This is normally considered satisfactory. However, the hydrogen samples were taken from material adjacent to the stringers, and the hydrogen content at these points is likely to be quite low due to diffusion from the metal into the stringer volume.

Tensile tests of bars taken from various areas of the shaft showed no alarming drop in physical properties at any point. In general, the tensile strengths met the original specifications, while the yield strengths were slightly low toward the centre. The most significant figures were low values for elongation and reduction of area near

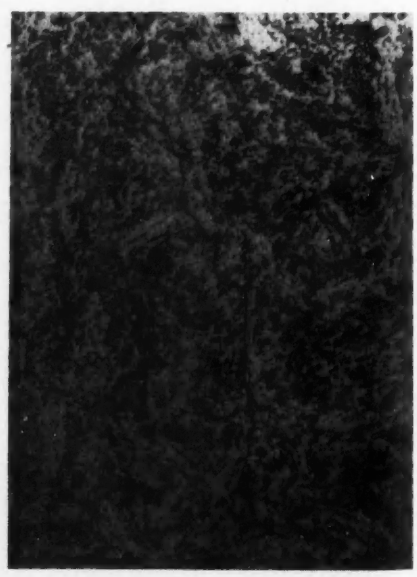


Fig. 6—Photomicrograph of a typical crack near the mid-radius of the forging. Magn. ×500

the bore, indicating a considerable loss in ductility. Some of the test bar fractures exhibited "fish eyes," which are bright spots resulting from the presence of hydrogen, a strong reducing agent. Also significant is the fact that test bars from areas of low ductility showed fully restored ductility after baking for two hours at 400 deg. Fah. This results from excess hydrogen in the metal which is removed by baking. Fig. 8 is a plot of the results of the Charpy V-notch impact tests. The transition temperature is high and probably above the average metal temperature during operation. This indicates a probability of high notch sensitivity and brittle rather than ductile failure under conditions of multi-axial stress.

A complete sonic test of one of the quadrants showed the presence of numerous indications, with general pattern and magnitude very similar to those recorded in the original sonic tests of the rough-machined forging. There was no indication of any significant change in the sonic pattern.

Analysis of Failure

A probable sequence of failure can be established with considerable accuracy from the examinations of fragments. While the failure was explosive in nature and occurred completely in only a very small fraction of a second, the sequence of events is believed by the builders to be shown in Fig. 7.

(1) Initial failure originated at the bore within the main body and progressed in a longitudinal plane both radially and toward the shaft ends, tending to split the main body into two halves. The actual pinpoint of origin cannot be determined positively, but a probable location has been identified as a granular area on one of the major cleavage surfaces adjacent to the bore.

(2) Extension of the primary failure into the shaft ends was limited by the clamping effect of the shrunk-on rings. These rings also restrained the two halves of the main body, and extremely high stresses were then set up at the fillet corners. Secondary failures from these corners immediately progressed in an inward direction toward the centre of the main body.

(3) As cracks from the fillet corners progressed in a direction to free the halves of the main body, strong centrifugal forces in each of these halves almost simultaneously split them into quarters. At the same time the centre portion of the material enclosing the bore in the main body fragmented, leaving conical segments attached to each of the spindle extensions. These segments, already split in two by the original primary failure, also quartered with the larger pieces.

(4) The quarter sections of each of the cones, eccentric and overhung and possibly not yet completely free of the main central pieces, tended to break off at the points of restraint under the rings. At some points these segments broke free; at others portions remained attached to the shaft extensions. While the sequence of failure shown in Fig. 7 was originally deduced solely from examination of the fragmentation of the Ridgeland shaft, it has since been confirmed with considerable accuracy by bursting tests of one-fifteenth size cast iron models.

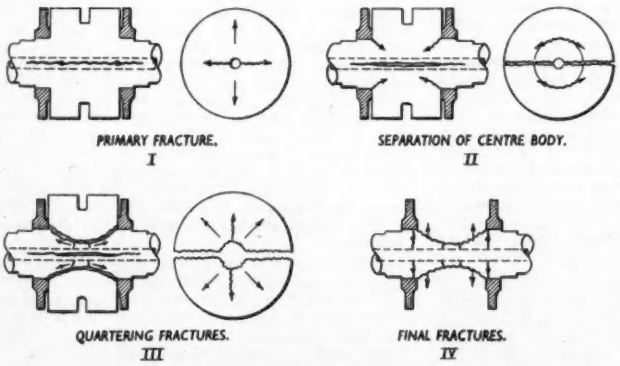


Fig. 7—Diagram indicating sequence of spindle failure in the opinion of the turbine builders

In accordance with accepted theory, brittle failure is associated with the inability of certain materials, particularly in large masses, to deform plastically in the presence of a stress at the root of a sharp notch. In such materials a moderate or low stress may be sufficient to initiate failure in the presence of notches or similar stress raisers. Brittle failures are characterised by sudden catastrophic cleavages at extremely high rates of propagation. Susceptibility to brittle failure is not revealed in the conventional tensile test, and the criterion in greatest use to-day in America is the Charpy impact test. For a specific material and heat-treatment, there is a narrow test-temperature range above which the impact energy absorbed is relatively high and the test-bar fracture exhibits ductile shear failure characteristics. Below this same temperature range the impact energy is low and the fracture is crystalline and brittle in appearance. The dividing line between ductile and brittle failure is referred to as the transition temperature. If the metal is used in a stressed structure at a temperature below its transition temperature, it is susceptible to brittle failure. The chemical analysis and heat-treatment for the Ridgeland forging were selected to give high tensile and yield strengths with good ductility. The Charpy impact tests, however, indicate a transition temperature somewhat above the operating temperature, causing high notch sensitivity. This condition exists with nearly all currently available high-strength materials for turbine spindles and generator rotors, and it requires great care to ensure that notches which could lead to brittle failure are not present.

Hydrogen flaking to-day is a major problem in the successful production of large turbine spindle forgings, particularly in sizes over approximately 50in in diameter. The conditions leading to the formation of flakes are fairly well established. Atomic hydrogen is highly soluble in molten steel and becomes available to a varying degree from the moisture present during melting. As the molten steel solidifies, hydrogen is evolved and forms molecular hydrogen gas in the micro-cavities and internal voids in the metal. As gas collects in these pockets, the resultant pressures may rise to extremely high values. The effects produced by hydrogen pressure depend upon another important factor. During the transformation of steel in cooling from high temperature, high thermal stresses are set up in large ingots due to the relative volume changes between core and rim. These transformation or cooling stresses, combined with the effect of entrapped hydrogen gas at points of already incipient weakness in the metal, may result in metallic separations or cracks variously identified as thermal cracks, segregation cracks, or hydrogen flakes.

The individual flakes vary considerably in size. Ultrasonic examination is therefore sometimes indeterminate in distinguishing between an individual flake and a harmless non-metallic inclusion or shrinkage cavity. Also, while flake orientation may be random, it tends to be in radial planes in large cylindrical forgings and thus edge-on to sound waves projected inwards normal to the forging circumference. The resultant ultrasonic response may be of low intensity. On the other hand, it is generally recognised to-day that flakes have the characteristic of being present in large numbers if they appear at all and of being fairly evenly distributed circumferentially in a band at about mid-radius in the forging. This band lies well inside the periphery of the forging and some distance out from the core or centre bore. Whereas the ultrasonic characteristics of the flakes are fairly well established to-day, they were not understood to this degree four or five years ago. This accounts for the judgment at that time, based on visual inspection of the bore, that the Ridgeland forging contained harmless inclusions rather than the more dangerous flakes.

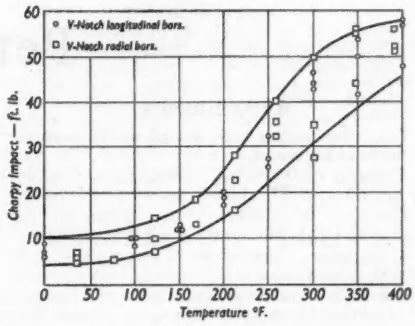


Fig. 8—Results of Charpy V-notch impact tests using specimens taken from mid-radius of the main spindle body

A study of the sequence of failure has indicated that it originated deep in the mass of the main body of the shaft. Metallurgical examinations have confirmed the fact that the metal was notch sensitive and susceptible to brittle failure. Various inspection techniques have shown the presence of an over-abundance of cracks in the form of flakes, providing the notches necessary to trigger a sudden and catastrophic failure of the shaft. The only point of uncertainty is the means by which the shaft maintained its integrity as long as it did. In the opinion of the builders it is probable that failure started when one or more of the numerous flakes in the main body near the bore extended slowly and approached the bore surface, a region of high local stress. At this instant the brittle nature of the material caused this surface crack to widen into a major separation at a very high rate of propagation.

It is evident from this investigation that the Ridgeland low-pressure turbine failure is centred around the metallurgy of large forgings. The susceptibility to brittle failure of the standard nickel-molybdenum-vanadium analysis in common use to-day is of great concern to the industry. Unfortunately, available alternate materials at the same strength levels offer little improvement. Materials totally immune to brittle failure, such as austenitic steel or some non-ferrous metals, have been proposed for turbine shafts, but their lower strength levels and other unfavourable characteristics make their use undesirable. The most logical attack on the problem seems to be in a continuing study of the factors influencing notch sensitivity, such as composition, heat-treatment, microstructure and processing.

Much development work within the steel-making industry will be required so that techniques and controls are established to eliminate all possibility of flakes in large forgings. The allowable hydrogen content in an ingot is probably well under 2 p.p.m., and ladle metal generally runs 4 p.p.m. or higher. One of the most promising current developments is the vacuum-casting process, which has been developed at Bochumer Verein in Germany and was described in our issue of April 29, 1955.

An equally important factor in large forging development is the improvement of inspection methods. As a matter of policy, all large turbine shafts of the company are bored axially, since optical and magnetic-particle inspection of the bore surface gives a good indication of the general quality of the forging. However, some of the more dangerous types of discontinuities may lie away from the bore and hence not be detectable by bore inspection. Ultrasonic inspection has now become a most important tool for the interior examination of metal masses, and intensive effort has been put into the development of improved sonic-inspection techniques. Forgings are now searched both radially and longitudinally at various frequencies, and techniques for searching radially outward from the bore are under development. Shear-wave crystals have been brought into use to improve the examination of areas formerly difficult to reach with straight crystals. Even more important than the development of new sonic-inspection techniques is the continually increasing knowledge enabling a better interpretation of the test results.

Personal and Business

Appointments

LORD GEDDES has been elected president of the Institute of Petroleum.

VISCOUNT CHANDOS has been re-elected president of the British Electrical Development Association.

CLARKSON (ENGINEERS), Ltd., Nuneaton, has appointed Mr. A. Macdonald as Glasgow manager.

COMMANDER CHRISTOPHER DREYER has been appointed sales manager of Vosper, Ltd., Portsmouth.

MR. J. G. THOM has been appointed sales manager for Northern Ireland of British Oxygen Gases, Ltd.

MR. P. BERNARD H. CUFF has been appointed a director of Solartron Electronic Business Machines, Ltd.

MR. J. H. NICHOLAS has been appointed head of the bituminous materials section of the Road Research Laboratory.

MR. C. W. EDWARDS has been appointed assistant (permanent way) in the civil engineering department of British Railways.

THE CUTLERY RESEARCH COUNCIL, Sheffield, has announced the appointment of Mr. C. N. Kington as director of research.

THE BRITISH INDIA STEAM NAVIGATION COMPANY, Ltd., has appointed Burness, Kendall and Partners, Ltd., as its naval architects.

MR. LESLIE TURNER, M.I.C.E., has been elected president of the British section of the Société des Ingénieurs Civils de France.

MR. C. W. J. MOUNTFORD, M.I.C.E., has been appointed divisional engineer in the N.E. division of British Transport Waterways.

SMITHS AIRCRAFT INSTRUMENTS, Ltd., announces the appointment of Mr. P. E. A. Talbot as technical sales and services manager in Canada.

W. H. HEYWOOD AND CO., Ltd., Bayhall Works, Huddersfield, states that Mr. G. T. Noble, sales manager, has been appointed a director.

MR. REGINALD TURNER, M.I.Mech.E., has been appointed chief engineer of Powell Duffryn Technical Services, Ltd., 19, Berkeley Street, London, W.1.

MR. C. F. NOSSITER, A.M.I.Mech.E., has been appointed chief engineer of J. A. Prestwich Industries, Ltd., Chelmsford Road, Southgate, London, N.14.

MR. C. E. KNIGHT has been appointed senior sales engineer in the fan division of Sturtevant Engineering Company, Ltd., Cannon Street House, London, E.C.4.

MR. PHILIP WRIGHT has been appointed general manager of the company which is to be formed shortly to take over the foundry and engineering activities of The Brightside Foundry and Engineering Company, Ltd.

METAL INDUSTRIES, Ltd., states that Mr. E. Bruce Ball has been appointed chairman of Brookhirst Switchgear, Ltd. He succeeds Mr. J. O. Knowles, who has served the company for thirty-seven years and who has now become honorary president.

MR. H. W. BREEZE, A.M.I.E.E., has been appointed works manager of the engineering department of W. T. Henley's Telegraph Works Company, Ltd., at Gravesend. He succeeds Mr. Ernest Moor, who has retired after forty-five years in the company's service.

THE LANCASHIRE DYNAMO GROUP states that Mr. D. C. Lorkin has become chairman of Crypto, Ltd., and that Mr. J. Parry has been appointed managing director. Mr. R. T. Sutton, A.M.I.E.E., has been appointed chief engineer at the Willesden works of Lancashire Dynamo and Crypto, Ltd.

MEGATOR PUMPS AND COMPRESSORS, Ltd., 43, Berkeley Square, London W.1, has appointed two additional representatives as follows :—Mr. B. Briggs, 67, Plane Tree Nest Lane, Halifax (South Yorkshire area), and Mr. Alan Billingham, 13, Mount View Road, Sheffield (East Midlands area).

HENRY BALFOUR AND CO., Ltd., Leven, Scotland, announces the appointment of Mr. Lindsay Burns, Jun., and Mr. I. M. O. Hutchison as joint managing directors. This follows the retirement of Mr. W. Lindsay Burns from the position of managing director, which he has occupied for twenty-seven years. Mr. W. Lindsay Burns will continue as chairman of the company.

THE UNITED STEEL COMPANIES, Ltd., announce the following appointments at the Steel, Peech and Tozer branch :—Mr. F. P. Wright, strip mill manager, and Mr. J. K. Walshaw, assistant strip mill manager ; Mr. W. E. Alexander, rolling mills superintendent ; Mr. N. D. Thomson, Brinsworth mill manager, with Mr. F. Tew, assistant manager ; Mr. W. F. Stroughair, assistant bar mill manager ; Mr. N. Stones, assistant manager 10in and 14in mills, and Mr. G. Morris, shift superintendent, bar mill.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., Trafford Park, Manchester, has announced the following appointments :—Mr. L. S. Robson, M.I.Mech.E., assistant chief mechanical engineer ; Dr. D. M. Smith, M.I.Mech.E., chief engineer, mechanical engineering development ; Mr. J. S. Hall, A.M.I.Mech.E., chief engineer, steam turbine engineering department ; Dr. W. H. Darlington, A.M.I.Mech.E., chief engineer, gas turbine and gear engineering department ; Mr. J. V. Bigg, A.M.I. Mech.E., chief engineer, condenser and heat exchange engineering department.

Business Announcements

MR. N. P. NEWMAN, chairman of the Council of Ironfoundry Associations, is now on a visit to Canada and the U.S.A.

MR. F. GORDON KAY, A.M.I.Mech.E., sales manager of Acheson Colloids, Ltd., is making a tour of South America.

STANDARD DEVELOPMENT COMPANY, Ltd., has moved to 171–174, Tottenham Court Road, London, W.1 (telephone, Euston 4400).

COMMANDER T. S. HORAN, sales director of Megator Pumps and Compressors, Ltd., 43, Berkeley Square, London, W.1, is making a tour of Sweden.

WILD-BARFIELD ELECTRIC FURNACES, Ltd., states that its applied high frequency division is to be transferred on May 28th from Cricklewood to Elecfurn Works, Watford.

MIDLAND SILICONES, Ltd., states that its electrical insulating compound MS4 is being distributed in the North of England by T. J. Grainger and Co., Ltd., 16, Eldon Square, Newcastle upon Tyne, 1.

MR. ARCHIBALD CAMPBELL, M.I.Mech.E., has retired from the position of chief mechanical engineer, Crown Agents for Overseas Governments and Administrations. He will continue to serve the Crown Agents as a consultant.

GLANMORFA, Ltd., Llanelly, states that for administrative reasons it is putting Glanmor Foundry Company, Ltd., into voluntary liquidation. The Glanmor Foundry will now be run by Glanmorfa Ltd., the liquidation involving only a change in name.

MR. W. A. GREEN, M.I.Mech.E., of Messrs. Green and Fox, consulting engineers, has moved to 13, Clarence Drive, Englefield Green, Egham, Surrey (telephone, Egham 3338). Mr. G. B. Fox, M.I. Mech.E., continues at 100, Wells Road, Malvern, Worcs.

Contracts

BIRLEC, Ltd., Erdington, Birmingham, has received an order for two "Lectromelt" arc furnaces from Round Oak Steel Works, Ltd.

HENRY MEADOWS, Ltd., Wolverhampton, has obtained a contract, valued at approximately £500,000, from the Egyptian Government, for diesel-electric generating sets.

W. T. HENLEY'S TELEGRAPH WORKS COMPANY, Ltd., has received from The Bogota Telephone Company, a second contract for cables, valued at 1,000,000 U.S. dollars. Another contract announced by W. T. Henley's Telegraph Works Company, Ltd., is that received from The Steel Company of Wales, Ltd., and valued at £250,000. The contract, which is divided into three stages, is for the supply and installation of 11kV and lower voltage paper, varnished cambric and P.V.C. insulated, lead and aluminium-sheathed cables, and also control cables, for the Velindre Works cold reduction plant.

A CONTRACT valued at over £1,250,000 for the construction of river works for the new Northfleet power station, Kent, has been let by the Central Electricity Authority to Taylor Woodrow Construction, Ltd. The consulting engineers are L. G. Mouchel and Partners, Ltd. The site of this 720MW thermal power station lies on the south bank of the Thames in the South Eastern Division of the Central Electricity Authority and is about a mile upstream from Gravesend. The work in this contract entails the construction of an 800ft long jetty, founded on 6ft diameter reinforced concrete cylinders and topped by an 18in reinforced concrete deck and 800ft of mass concrete wharf wall, poured *in situ* in permanent sheet steel piled cofferdam. Pulverised fuel ash is to be used in the mass concrete work to replace a portion of the cement. A large pump and screen chamber and the intake and outfall works for the cooling water system are also included. Work started in April on the contract, which is expected to take two and a half years to complete.

Miscellanea

CARRIER-BORNE FIGHTER AIRCRAFT.—Aboard H.M.S. "Ark Royal" the carrier trials of the "D.H.110" all-weather fighter have now been satisfactorily completed. The aircraft, which was illustrated in our issue of January 13th, is powered by twin Avon engines and can be allowed to reach supersonic speeds in a dive. It is claimed that it can carry in addition to a crew of two and complex radar and fire-control equipment, four 30mm Aden guns, guided missiles, and fuel for a lengthy operational mission.

DUAL PURPOSE CLUTCH.—Automotive Products Company, Ltd., of Leamington Spa, has added to the Borg and Beck range of clutches one which includes provision for a power take-off. This takes the form of an auxiliary clutch, of similar friction area, mounted on the pressure plate assembly of the main unit. The friction plate of the outer clutch is splined to a hollow shaft co-axial with the normal output. Both clutches are disengaged through sets of three adjustable linkages, actuated through ball thrust bearings ; the need for a "neutral" in any drive which is to be freed from the prime mover for a large proportion of its running time therefore remains. The dual purpose clutch is available in an 11in diameter size.

OIL COMPANY'S FILMS.—Last week the British Petroleum Company, Ltd., showed three films, in colour, about oil. The first film, with the title "We Found a Valley," shows the building of the Aden refinery and illustrates some of the problems which had to be overcome together with something of the life of those engaged in its construction. The next film, "Speed the Plough," took the form of an animated cartoon and shows the historical development of mechanical farming from the middle ages to the present day. Entitled "The New Explorers," the third film records aspects of the life and work of those engaged in the search for oil and includes scenes in Canada, Zanzibar, Papua, Trinidad and Sicily.

MECHANICAL HANDLING FILM.—Last week the Mechanical Handling Engineers' Association presented a documentary film entitled "The Seed is Sown," which serves as a supplement to earlier films "Mechanical Handling" and "Conveyors as Your Servants." The film is concerned with the grain handling industry and deals with grain grown abroad and at home, sowing and reaping, the production of fertiliser and the handling of grain at ports. Reception and storage of grain are shown and the final section deals with the manufacture of certain end products. The 16mm film is in colour with sound commentary and has a running time of about twenty-six minutes and can be obtained on loan from the Association at 94/98, Petty France, London, S.W.1.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—At a general meeting of the North East Coast Institution of Engineers and Shipbuilders, held on April 20th, Mr. J. Calderwood, M.Sc., read his paper "Geared Diesel Marine Machinery, with Particular Reference to Two Installations of Different Types." The paper discusses generally the increasing advantage of the use of geared diesel engines for marine propulsion and describes in detail two particular installations. One or two geared drive arrangements are briefly examined and a note given upon couplings, and this is followed by a description of two installations of relatively high power. These are the whale catcher "Setter IX," which has two main engines, totalling 3500 s.h.p., which drive a single variable pitch propeller through a single reduction gearbox and electro-magnetic couplings ; and the "Princess of Vancouver," which has twin screws, each driven by two diesel engines, each rated at 1575 b.h.p., through a gearbox and hydraulic coulpings.

LEICESTER FIRM'S SEVENTIETH ANNIVERSARY.—To mark its seventieth anniversary, Taylor Taylor, and Hobson, Ltd., of Leicester, has published an interesting book dealing with its history and products. The firm started in 1886 when Thomas Smithies Taylor, with a capital of about £300, rented the top floor of a factory in Slate Street, Leicester, for making lenses. He was joined by his brother, William Taylor, some months later, and in 1888 the brothers were joined by W. S. Hobson. In 1893 the firm acquired the manufacturing rights of the "Cooke" lens from Dennis Taylor, the optical manager of T. Cooke and Sons, of York. From that time the firm has steadily grown and its "Cooke," "Aviar" and "Speed Panchro" and other lenses are now used throughout the world. A point of interest is that more than 80 per cent of the lenses now used in the film studios of the world come from Leicester. The book also describes how, side-by-side with its lens work, other branches for the manufacture of the firm's engraving machines and precision optical measuring equipment were established and extended.

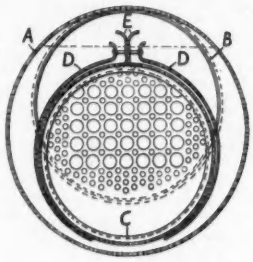
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

STEAM GENERATORS

746,840. May 4, 1953.—WATER CIRCULATION OF BOILERS, William Charles Ikeson, 58, Southview Drive, South Woodford, London, E.18.

The invention relates to water circulation arrangements for boilers—for example, of the Lancashire or locomotive type—having one or more horizontally disposed cylindrical furnace tubes. As the drawing shows, the boiler has an outer shell *A* and a boiler barrel *B*. The shell encloses a cylindrical corrugated furnace tube *C*, around which are spaced the substantially semi-cylindrical shell convection plates *D*. The top portion of each of the convection plates *D* is turned up to guide the water currents into a vertical stream before they spill over the side, the upper edges of the plates being arranged to protrude



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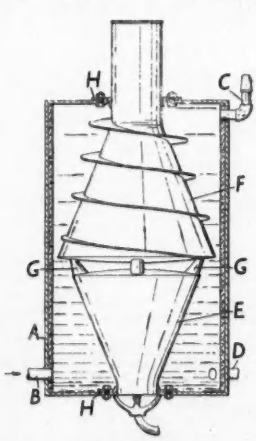
just above the working water level in order to promote the flow and circulation. A vertical partition plate *E* is fitted to separate and guide the two streams as they rise from each side of the furnace tube. This partition plate prevents any interruption at the apex of the furnace tube where the two streams meet and overcomes the formation of eddy currents at this point by retaining a constant and regular cross-sectional area for their passage. Various modifications may be made within the scope of the invention. —*March* 21, 1956.

744,684. May 14, 1953.—IMPROVEMENTS RELATING TO BOILERS, Maurice Charles Halliday, 18, St. Georges' Road, Brighton, Sussex.

The invention relates to boilers for industrial, domestic or other purposes. Its object is to provide heat-exchange means for incorporation in a boiler which is efficient in operation and cheap to construct. As shown in the drawing the boiler comprises a tank or casing *A*, with water inlet *B*, outlet *C*, and drainage connection *D*. According to the invention heat-exchange means fitted within such a tank comprise a lower compartment *E* in the form of an inverted cone open at its base, and an upper compartment *F* in the form of an upright cone open at its apex. These



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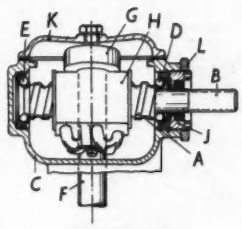
two compartments each extend through substantially half of the length of the tank, and are connected together by tubular conduits *G*, four being shown in the drawing. The open ends of the conical compartments are of tubular form, and are fitted with flanged collars *H* forming water seals for securing them in the tank. In operation heat is applied at the open mouth at the base of the lower compartment *E*. The shape of the lower compartment ensures that complete combustion occurs and during this stage some heat is absorbed by the surrounding liquid. The hot gases pass upwards through the conduits *G*, by which they are directed to, and flow upwards against, the tapering wall of the upper compartment, during which heat passes to the surrounding liquid. In order to assist such conduction and dissipation of heat the upper compartment *F* may be fitted externally with vanes or gills.—*February* 15, 1956.

ROAD TRANSPORT

747,282. January 27, 1954.—HOUSING ARRANGEMENT OF STEERING GEARS, Daimler-Benz Aktiengesselschaft, Stuttgart-Untertürkheim, Germany.

The invention relates to a new housing arrangement for the screw mechanism of steering gears in motor vehicles. Referring to the drawing, a screw *A* is connected to the steering wheel by a spindle *B* and is mounted in a housing *C* in anti-fritcion thrust bearings *D* and *E*. The steering lever spindle *F* carrying the steering lever *G* is also supported in a bearing in the housing. A nut *H* enclosing balls running in the thread of the screw spindle is pivotally connected with the steering lever *G*. A ring *J* closes the gap between the housing *C* and the spindle *B*, the ring being screwed into an aperture in the housing. A cover *K* closes a second opening in the housing in the region of the nut *H*. A locknut *L* prevents undesired turning of the ring *J* after any adjustment in its aperture in the housing. The axis of the spindle *F* is perpendicular to the cover *K*.



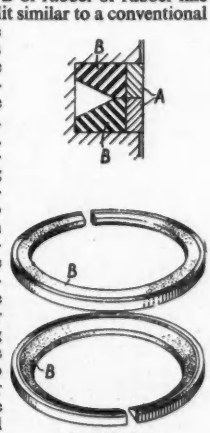
No. 747,282

As will be seen from the drawing, the thrust bearing *E* is in a hollow boss formation on the housing. The bearing *D*, however, is mounted in the housing itself, but in a through hole. It will be apparent that after loosening the locknut *L* the ring *J* can be turned so as to give fine degrees of adjustment for relieving tightness or taking up slackness in the thrust bearings. —*March* 28, 1956.

POWER TRANSMISSION

744,651. November 18, 1953.—SEALING RINGS, Wellworthy, Limited, Radial Works, Stanford Road, Lymington, Hampshire. (*Inventors: John William Howlett* and *Kenneth Arthur Blacklock.*)

The invention relates to sealing rings and arrangements for movable members. Referring to the drawing, each sealing ring comprises a metal ring *A*, preferably made of cast iron, to the internal periphery of which is bonded a ring *B* of rubber or rubber-like material. The rings are split similar to a conventional piston ring. The side face of each rubber ring is chamfered towards the bore, the chamfer preferably not extending for the full width of the side face. For achieving a good seal, two such rings are assembled side-by-side in a ring groove with their chamfered side faces adjacent to one another as shown in the upper view. The combined radial depth of the rubber and metal portions of the composite ring is made slightly greater than the depth of the ring groove so that, when the rings are compressed to close the gaps, the rubber will be pressed against the groove base. The radial compression of the rubber provides the necessary wall pressure between the periphery of the ring and the cylinder against which it moves. The pair of rings are arranged in the groove with their gaps displaced from one another. With this arrangement any oil or other fluid which leaks through the gap of the ring which is on the pressure side, will flow into the cavity between the rings and assist in loading the rings on to the surface against which they bear.—*February* 8, 1956.



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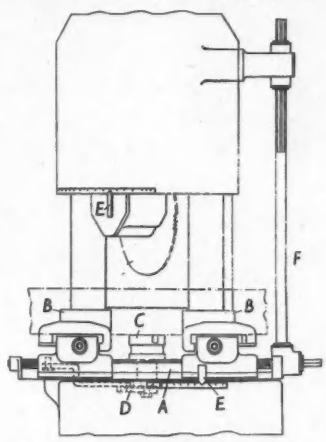
MACHINE TOOLS

745,032. December 21, 1953.—METAL SAWING MACHINES, S. Russell and Sons, Ltd., Bath Lane, Leicester. (*Inventor: Norman Henry Philipson.*)

On the circular sawing machine is a guide *A* for a pair of work vices *B*, which are movable relatively to each other by a right and left hand screw, by hydraulic or other means. Between the vices there is mounted on the guide a work support *C* which may consist of a circular block, and which is angularly adjustable about a vertical axis coinciding with the pivot-axis of the saw blade. In the upper face of the work support is a transverse slot of sufficient depth to accommodate the lower part of the blade after it has severed the work. To ensure a rigid clamping of the workpiece during the cutting operation, the vices should be as close as possible to the work support. When, however, it is required to sever the



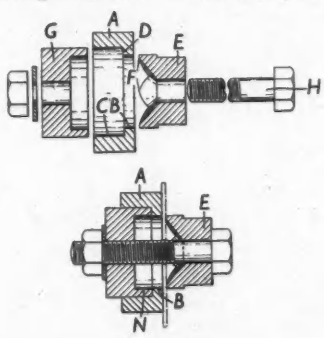
No. 745,032

workpiece along an oblique line, the distance between the vices must be increased sufficiently to accommodate the saw. To enable the vices to be at all times properly positioned, the work support *C* has secured to it an arm *D* which is connected by a link to one of the vices, so that for a given position of the slot in the support the distance between the vices is correspondingly varied in a predetermined manner. For convenience in correlating the slot in the work support with the plane of the saw blade, a graduated scale and pointer *E* may be provided in association with the work support or one of the vices. Alternatively or additionally (as shown), the vice screw may be in driving engagement with a vertical shaft *F* for effecting the angular setting of the blade. To permit the vertical movement of the slide relative to the shaft *F*, the upper end of the latter is splined and slidably engages a hollow pinion or worm in the part extending from the saw slide, this pinion being in mesh with mechanism (not seen) within the slide for setting the angle of the blade. Thus by setting the work support to the required angle the blade and vices are automatically and correspondingly set.—*February* 15, 1956.

TOOLS AND WORKSHOP APPLIANCES

748,028. March 23, 1953.—FORMING HOLES IN SHEET MATERIAL, Davis Sheet Metal Engineering Company, Ltd., and Thomas Davis, both of the company's address, 54, Islington Park Street, London, N.1.

The invention relates to means for forming holes in sheet metal where the material or article is relatively inaccessible or where a conventional punching or piercing machine cannot conveniently be used.



No. 748,028

As the drawing shows, a die member *A* comprises a thick disc of steel having a die aperture *B* of the required size. The die member *A* is recessed or counterbored at *C* at the rear of the die face to provide an internal shoulder *D*. A punch comprises a short

steel cylinder *E* having a face a close fit in the aperture *B* and a reduced diameter a short distance to the rear of the face. The face is shaped to four chisel-like edges *F*, between which the material is removed in a curved vee shape. The interior of the punch member is formed with a conical recess, which joints a central bore. This formation of the punch face is to give a regular and progressive piercing action. A positioning member or bolster *G* is provided to enter the counterbore *C* of the die and is formed to abut against the shoulder *D*. The positioning member comprises a steel cylinder which is an easy fit in the counterbore *C* and is formed with an interior circular recess in which the punch face is an easy fit. The diameter of the recess is sufficiently larger than that of the punch face to ensure that the blank will freely enter and be readily removed when the parts are separated after the piercing operation has been performed. The member *G* has a central bore similar to that of the punch and both bores are adapted to slide over a stem *H*, preferably of high-tensile steel, upon which the various parts can be assembled. The arrangement is such that by threading a nut on the bolt with an interposed washer between the nut and the member *G* the assembly can be contracted to cause the punch member to pass through the die aperture.—*April* 18, 1956.

Launches and Trial Trips

KELSO PATON, trawler ; built by John Lewis and Sons, Ltd., for the Ardrossan Trawling Company, Ltd.; length overall 130ft, breadth 25ft, depth 12ft, gross tonnage 274 ; fish room 6400 cubic feet, electric trawl winch, 1000 fathoms 2¼in warp, one 20kW diesel-driven generator, one 10kW diesel-driven generator, one diesel-driven trawl winch generator ; British Polar M.44 M diesel engine, 640 b.h.p. at 250 r.p.m. Trial, March 15th.

HINNITES, oil tanker ; built at the Walker yard of Vickers-Armstrongs, Ltd., for Shell Bermuda Overseas Company, Ltd.; length between perpendiculars 530ft, breadth moulded 69ft 3in, depth moulded 39ft, deadweight 18,000 tons, speed 14½ knots ; thirty-three cargo oil tanks ; four 400 tons per hour turbine-driven cargo pumps, two 150 tons per hour stripping pumps ; two 550kW turbo-alternators, one 200kW diesel-driven alternator ; one set of double reduction geared turbines, 8250 maximum s.h.p. at 130 propeller r.p.m. Launch, March 28th.

BAMENDA PALM, cargo liner ; built at the Neptune Works of Swan, Hunter and Wigham Richardson, Ltd., for the Palm Line, Ltd.; length between perpendiculars 415ft, breadth moulded 58ft, depth moulded to shelter deck 35ft, five cargo holds, one 75-ton, six 10-ton and ten 5-ton derricks, electric deck machinery ; three 250kW diesel-driven generators, one 30kW diesel-driven generator ; Swan, Hunter-Doxford oil engine, four cylinders, 670mm diameter by 2320mm combined stroke, 4500 b.h.p. at 118 r.p.m. Trial, March 28th.

BURWAH, cargo ship ; built by the Burntisland Shipbuilding Company, Ltd., for Australian Steamships Proprietary, Ltd.; length between perpendiculars 290ft, breadth moulded 44ft 6in, depth moulded 20ft 10in, deadweight 3400 tons ; four holds, electric deck machinery, ten 5-ton and two 7-ton derricks ; four 100kW diesel-driven generators, British Polar diesel engine, nine cylinders, 340mm diameter by 570mm stroke, 1440 b.h.p. Trial, March.

EASTERN GULF, oil tanker ; built by the Chantiers de l'Atlantique (Penhoet Loire) for Afran Transport ; length overall 690ft, length between perpendiculars 661ft 2in, breadth 86ft 9in, depth 45ft, draught 33ft 11in, deadweight 37,400 tons, trial speed 17 knots ; one set of double reduction geared C.E.M.-Parsons turbines, 18,000 s.h.p., steam at 640 lb per square inch and 850 deg. Fah. supplied by two Foster-Wheeler water-tube boilers. Trial, March.

Catalogues and Brochures

ZINC DEVELOPMENT ASSOCIATION, 34, Berkeley Square, London, W.1.—European Bulletin No. 2, dealing with the use of zinc alloy pressure die castings as hardware articles.

NEWMAN, HENDER AND CO., Ltd., Woodchester, Stroud, Glos.—Catalogue entitled "Forged Steel Valves," illustrating a range of valves, giving dimensions and working pressures.

DAVEY, PAXMAN AND CO., Ltd., Standard Ironworks, Colchester, Essex.—Illustrated brochure dealing with rotary vacuum filters, giving details of design and general construction.

GEORGE KENT, Ltd., Luton, Bedfordshire.—Publication No. 342/955, dealing with Wobbe index controller developed for the automatic control of supplies of town's gas in factories.

GEORGE KENT, Ltd., Luton, Bedfordshire.—Publication No. 350, dealing with pressure, temperature and combined pressure and temperature ranges for commander-class instruments.

QUALTERS AND SMITH BROS., Ltd., Old Foundry, Barnsley, Yorks.—Leaflet dealing with a 10" capacity machine saw with two-speed gear selection, giving details of design and specification.

BARLOW-WHITNEY, Ltd., Sales Office, 2, Dorset Square, London, N.W.1.—Catalogue entitled "Factory and Workshop Process Heating Appliances," describing a range of portable industrial heating equipment with wide applications in many industries.

SANDERSON BROTHERS AND NEWBOULD, Ltd., Attercliffe Steelworks, P.O. Box No. 6, Newhall Road, Sheffield.—Folder dealing with "Celfor" shallow hardening steel and giving its features and uses.

DELORO STELLITE, Ltd., Highlands Road, Shirley, Birmingham.—Publication B33, giving details of a heavy duty "39HD" parting tool designed to cut over a wide range of speeds and feeds.

KELVIN AND HUGHES (MARINE), Ltd., 99, Fenchurch Street, London, E.C.3.—Leaflet No. M240, giving details of MS24/CRT "Kingfisher" echo sounder used for deep sea near-bottom echo fishing.

BRITISH JEFFREY-DIAMOND, Ltd., Stennard Works, Wakefield, Yorks.—Publication No. 1516, giving details of a "Type C.20" armoured conveyor used in mining or as a feeder conveyor in the loader gate.

BLAW KNOX, Ltd., 90-94, Brompton Road, London, S.W.3.—Leaflet describing a pneumatic concrete placer used for general building, foundation work tunnel lining and reservoir and dam constructions.

EXPANDITE, Ltd., Chase Road, London, N.W.10.—Leaflet dealing with "Pli-astic" rubber bitumen sealing compound, used for horizontal joint sealing in concrete runways, roads and factory floors.

NORTON GRINDING WHEEL COMPANY, Ltd., Welwyn Garden City, Herts.—Folder giving details of the "Norton B.D." reinforced grinding wheel for use on portable grinding and sanding machines.

J. M. J. MAUS, Ltd., 35, New Broad Street, London, E.C.2, agents for Fried. Krupp, Essen, Germany.—Catalogue giving the history and outline of Krupp enterprise with illustrations from workshop and field.

HUNTING GEOPHYSICS, Ltd., 6, Elstree Way, Boreham Wood, Herts.—Leaflet entitled "Aerial Surveying for Mineral Deposits," dealing with metals revealed in Norway, Canada and Philippines by a British technique.

DAVEY, PAXMAN AND CO., Ltd., Standard Ironworks, Colchester, Essex.—Brochure dealing with the principles of the packing and service system which this company operates from its Colchester headquarters.

THE NATIONAL GAS AND OIL ENGINE COMPANY, Ltd., Ashton-under-Lyne, Lancashire.—Booklet entitled "Have a Look Around National," giving the history of this company in the gas and diesel engine industry.

TALBOT STEAD TUBE COMPANY, Ltd., Green Lane, Walsall.—Illustrated catalogues dealing with "Metior" stainless steel tubes and fittings, A range of products booklet, giving applications and specifications.

THE POWER-GAS CORPORATION, Ltd., Parkfield Works, Stockton-on-Tees.—Catalogue entitled "Controlled Crystallization by the Krystal Process," illustrating materials that are and can be used and sold in crystalline form.

G.W.B. FURNACES, Ltd., P.O. Box No. 4, Dibdale Works, Dudley, Worcs.—Three leaflets dealing with a range of mains frequency induction melting equipment covering three basic ranges, i.e. cast irons, copper alloys and light alloys.

SHANDON SCIENTIFIC COMPANY, Ltd., 6, Cromwell Place, London, S.W.7.—Leaflets illustrating and describing a "Pollux" integrating calorimeter of the mechanical type and a gas density recorder for the continuous recording of the density of gases.

LEAD DEVELOPMENT ASSOCIATION, Eagle House, Jermyn Street, London, S.W.1.—A series of brochures entitled "Lead Paints To-day," "Lead in Cable Manufacture," and "Lead for Batteries," describing the use of lead for each specific product.

THE BRONX ENGINEERING COMPANY, Ltd., Lye, Near Stourbridge, Worcs.—Illustrated catalogue dealing with a range of plate bending rolls used for cylindrical or conical work, also catalogue illustrating guillotine shears, giving dimensions and performance figures.

IMPERIAL CHEMICAL INDUSTRIES, Ltd., Imperial Chemical House, Millbank, London, S.W.1.—Brochure entitled "I.C.I. Welding Rods and Brazing Materials," dealing with the methods of jointing non-ferrous metals and alloys, showing tables, packaging and identification.

CANTIE SWITCHES, Ltd., New Ferry, Birkenhead.—Publication No. 23001, giving details of short-circuit tests carried out on Cantie Buxton certified flameproof distribution switchboards at an A.S.T.A. proving station. Oscillograms of the busbar and switch "Make" tests are reproduced.

THE VARLEY MAGNET COMPANY, Cambridge Row, Woolwich, London, S.E.18.—Leaflet giving details in the design and production of electrical coils, transformers, solenoids, electromagnets, magnetic clutches, lifting magnets, magnetising equipment and motor and vibrator assemblies.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, May 11th.—BRISTOL AND WEST OF ENGLAND BRANCH : Grand Hotel, Bristol, Lecture by G. L. Leighton, 7.30 p.m.
Mon., May 14th.—CENTRAL LONDON BRANCH : St. Ermins Hotel, Caxton Street, London, S.W.1, "Water Heating," 7 p.m.——N.W. LONDON BRANCH : Century Hotel, Forty Avenue, Wembley Park, "Atomic Energy in Industry," A. R. Dixon, 8.15 p.m.
Tues., May 15th.—BOURNEMOUTH BRANCH : Grand Hotel, Firvale Road, Bournemouth, Annual General Meeting, 7.15 p.m.——PORTSMOUTH BRANCH : "Air Balloon," 598, Commercial Road, Mile End, Portsmouth, "Salesmanship," R. S. Farr, 7.30 p.m.
Thurs., May 17th.—SOUTHAMPTON BRANCH : "Pilgrim Room," Polygon Hotel, Southampton, Joint Meeting with the Electrical Association for Women, 7 p.m.——WATFORD BRANCH : Compasses Hotel, High Street, Watford, "Electricity in the Oil Industry," J. Miller, 8.15 p.m.
Fri., May 18th.—STOKE AND CREWE BRANCH : Royal Hotel, Crewe, Annual General Meeting, 7.30 p.m.
Sat., May 19th.—KENT BRANCH : Royal Star Hotel, Maidstone, Annual General Meeting, 7.30 p.m.

CHADWICK PUBLIC LECTURE

Mon., May 14th.—Barnes Hall, Royal Society of Medicine, 1, Wimpole Street, London, W.1, "The Influence of Chadwick on American Public Health," Huntington Williams, 5 p.m.

INCORPORATED PLANT ENGINEERS

Wed., May 16th.—KENT BRANCH : Bull Hotel, Rochester, "Air Conditioning in Engineering," K. W. Dale, 7 p.m.
Fri., May 25th.—BIRMINGHAM BRANCH : Imperial Hotel Birmingham, "The Legal Aspect of Boiler Operation and Maintenance," G. A. Anderson, 7.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., May 14th.—LEICESTER CENTRE : E. Midlands Electricity Board, Charles Street, Leicester, Annual General Meeting, 6 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., May 15th.—COVENTRY SECTION : Room A5, Technica College, Coventry, "Investment Casting for Aircraft Engines," D. F. B. Tedds, 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., May 14th.—STUDENT LECTURE : 85, Minories, London, E.C.3, "The Shipping Industry," A. Watson, 6.30 p.m.

INSTITUTE OF NAVIGATION

Wed., May 16th.—Royal Geographical Society, 1, Kensington Gore, London S.W.7, The James Cook Exhibition at Greenwich, G. P. B. Naish, "Ballooning," C. H. Gibbs-Smith, D. N. Harrison, and C. S. Durst, followed by a Discussion, 5 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

To-day, May 11th.—S. WALES GROUP : S. Wales Institute of Engineers, Park Place, Cardiff, "The Commer 'T.S3' Two-Stroke Diesel Engine," E. W. Coy, 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., May 15th.—ORDINARY MEETING : JAMES FORREST LECTURE: Great George Street, Westminster, London, S.W.1, "Marine Physics," G. E. R. Deacon, 5.30 p.m.
Tues., May 29th.—WORKS CONSTRUCTION MEETING : Great George Street, Westminster, London, S.W.1, "Kwinana Jetty," Peter Murray and D. N. Collett, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day to Sun., May 11th to 13th.—UTILISATION SECTION : Summer Visit to Harrogate.
Mon., May 14th.—EDUCATION DISCUSSION CIRCLE : Savoy Place, London, S.W.1, Discussion on "An Elementary Presentation of the Principles of Magnetism and Electromagnetic Induction with Demonstrations," opened by K. A. Hayes, 6 p.m.——LONDON GRADUATES' AND STUDENTS' SECTION : Savoy Place, London, W.C.2, Annual General Meeting, followed by a Film Show, 6.30 p.m.
Tues., May 15th.—UTILIZATION SECTION : Savoy Place, London, W.C.2, "Mine Locomotives," T. E. Green, 5.30 p.m.
Wed., May 16th.—SUPPLY SECTION : Savoy Place, London, W.C.2, "The Sir Adam Beck Generating Station No. 2 at Niagara : A Major Canadian Hydro-Electric Development," R. L. Hearn, 5.30 p.m.
Thurs., May 17th.—Savoy Place, London, W.C.2, Annual General Meeting, Corporate Members and Associates only, 5.30 p.m.; "Appearance Design," Sir Gordon Russell, 6.30 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Fri., May 18th.—N.E. BRANCH : Crown Hotel, Clayton Street, Newcastle upon Tyne, Annual General Meeting, 6.15 p.m.; Annual Dinner, 7.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, May 11th.—GENERAL MEETING IN CONJUNCTION WITH THE INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, "The Influence of the Gas Turbine Axial-Flow Aero-Engine on Blade Manufacturing Methods," R. R. Whyte, 5.30 p.m.
Wed., May 16th.—LONDON GRADUATES' SECTION : Visit to Peak, Frean and Co., Ltd., Bermondsey, S.E.16, 10.15 a.m.; 1, Birdcage Walk, Westminster, London, S.W.1, Annual General Meeting, Paper by F. Porges, 6.30 p.m.
Thurs., May 17th.—E. MIDLANDS GRADUATES' SECTION : Room 104, College of Technology and Commerce, "The Newarke," Leicester, Annual General Meeting, followed by Films, 6.45 p.m.——N.W. GRADUATES' SECTION : Visit to Leyland Motors, Ltd., Leyland, Lancs, 1.15 p.m.
Sat., May 26th.—YORKSHIRE GRADUATES' SECTION : Visit to Ferrybridge "B" Power Station and Monk Fryston Switching Station, 10 a.m.
Mon., May 28th.—MIDLAND GRADUATES' SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, Annual General Meeting, followed by Chairman's Address, 6 p.m.

INSTITUTION OF MINING AND METALLURGY

Thurs., May 17th.—Geological Society, Burlington House, Piccadilly, London, W.1, Annual General Meeting, open to Corporate and Non-Corporate Members only, 4 p.m.; Presentation of Awards, Induction of President ; Presidential Address, C. W. Dannatt, 5.15 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., May 16th.—WOLVERHAMPTON GRADUATE SECTION : Technical College, Wulfruna Street, Wolverhampton, "The Use of Air-Operated Fixtures in Mass Production," J. F. Smith, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Thurs., May 24th.—11, Upper Belgrave Street, London, S.W.1, Annual General Meeting, 6 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., May 15th.—SECTION LECTURE : 4, Hamilton Place, London, W.1, "Medical Aspects of Flight Comfort and Efficiency," A. Buchanan Barbour, 7 p.m.
Thurs., May 17th.—Royal Institution, Albemarle Street, London, W.1, Wilbur Wright Lecture, "The Aerodynamic Art," Sir William S. Farren 6 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Wed., May 23rd.—LAND SURVEYORS' GENERAL MEETING : 12, Great George Street, Westminster, London, S.W.1, "The Striding Level," J. S. Sheppard, 5.30 p.m.
Mon., May 28th.—12, Great George Street, Westminster, London, S.W.1, Annual General Meeting, 5 p.m.

ROYAL SOCIETY OF ARTS

Wed., May 16th.—John Adam Street, Adelphi, London, W.C.2, "Electronic Photography," C. G. Mayer, 2.30 p.m.

SCIENTIFIC FILM ASSOCIATION

Wed. to Fri., May 16th to 18th.—Ashorne Hill, Near Leamington Spa, Conference on Film as an Aid to Management.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., May 29th.—Manson House, 26, Portland Place, London, W.1, Annual General Meeting, "Process Analytical Instrumentation," A. G. Stanley and J. F. Brown, 6 p.m.

UNIVERSITY OF LONDON

To-day, May 11th.—King's College, Strand, London, W.C.2, a Course of Four Lectures on Civil Engineering, Hjalmar Granholm, 5.30 p.m.

WOMEN'S ENGINEERING SOCIETY

Mon., May 14th.—LONDON BRANCH : 45, Great Peter Street, Westminster, London, S.W.1, "Mining Machinery," 7 p.m.